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Electrical Review.

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ELECTRIC LOCOMOTION.

WE progress slowly, if surely, here in England; but in America once an idea takes root, or a fact becomes known, its practical and logical consequences are worked out with what seems to our more deliberative minds startling rapidity. In this country, whatever may be said with regard to the electric light and the telephone, only the very slightest commercial advantage has been taken of the knowledge which has long been promulgated upon the subject of electric locomotion, while in America, where a year or so ago the meaning of electric railroads was scarcely known, applications of the principles of this mode of traction are multiplying daily. A franchise has just been secured from the New York Board of Aldermen by a street railway company of the same city enabling the latter to work a certain portion of its lines by means of electricity according to the system of Bentley and Knight. This franchise marks an important epoch in passenger traffic, as the road will be the first of its kind to run through the crowded streets of a large city. The design of the new line is to connect the principal railway ferries of the west side of the river with Fulton Ferry at one fare, and to give easy communication between Washington and Fulton markets. The line will be a double-tracked one, running from the Fulton Ferry through Fulton Street to Broadway, over and across Broadway, continuing through Fulton Street to West Street; through West Street to Cortlandt Street, and then connecting with the foot of Chambers Street on the one side and Burling Slip on the other. These streets comprise the busiest parts of New York, and it may be assumed that the Aldermen were thoroughly satisfied of the safety and easy manipulation of the Bentley-Knight cars before consenting to their employment under the conditions they will have to encounter. It is claimed that the cars, which are provided with rounded fronts, can travel at the rate of 15 miles an hour, or can be moved so imperceptibly as to force their way without accident through a crowd. The average speed will be about six miles an hour, and the absence of horses reduces the space occupied by the necessities of transportation to a minimum. The character of the proposed road may be gathered from the sixth clause of the grant, which reads thus: "The plans upon which this North and East River Railway shall be built and operated are those of the Bentley-Knight Electric Railway Company, and are described as follows: The plant consists of a stationary source of power—engines, boilers and dynamo electric machines—which may be placed at an extreme end of the line, at tidewater, or at a station; a conduit running from the source of power to and along the whole length of the line, containing stationary and permanent conductors, which receive and distribute the electric current to the motors placed under the cars and geared to the wheels or axles, and a depending conductor which, passing through a slot in the conduit and sliding in contact with the stationary conductors, maintains unbroken connection with the source of power." The confident anticipation of the projectors is that the cars will be running in April. The working of this system in the streets of New York will be watched with interest by electricians everywhere, for upon the results obtained calculations for future attempts in the electrical propulsion through city streets of passenger-carrying vehicles will be based.

Seeing what has been and is being done in the United States, it is remarkable that such little progress has been made in this country. True, we have the Blackpool Tramway, the two Irish tracks, and Mr. Volk's little line on Brighton beach; but these, however satisfactory in themselves as realisations of theoretical promise, are far too insignificant to be pointed to as representative of the industrial accomplishment of a great nation. The facts and the possibilities in the direction of electrical traction are well ascertained and may be readily learnt by those who wish to know them. The average cost of horse traction is probably about 7½d. or 8d. per car mile; under some conditions the cost of horses alone reaches this figure, as for instance, on the exceptionally steep gradients of Edinburgh, where it is 7¾d.; the average expenditure on horseflesh, however, may be taken as about 6½d. per car mile, the addition of a little over 1d. per car mile for drivers and other sources of expenses, bringing the total cost to the point we have mentioned. For electrical haulage the cost, allowing wide margins, need not exceed 4d. per car mile. These being the facts it is to the discredit of our commercial genius that this source of economy has been so long neglected. Development, of course, is only a matter of time, but too much time has already been wasted. In the coming Session of Parliament, we believe a Bill will be submitted for its final reading which, if passed, will enable the North Metropolitan Tramways Company to employ electricity on its lines. No opposition to the Bill is anticipated, and almost immediately upon its passing the company will run Mr. Elieson's electrically-propelled carriages alternately with the horse-drawn cars now employed. When this innovation has once been proved a success, other conservative tramway companies will doubtless follow the example of the North Metropolitan, and within a year or so we may expect to find that the employment of electric cars is no longer regarded as remarkable.

Sir Chas. Bright's Address.—A correspondent calls attention to the presidential address delivered before the Society of Telegraph-Engineers and Electricians last week, and to the impression left upon his mind at the conclusion. For the benefit of our readers who could not be present at the meeting, and in consideration of the circumstances under which it was delivered, we reproduce the speech in full.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.

By A. RECKENZAUN.

(*Continued from page* 609, *Vol.* 19.)

THE charges and discharges were made with a series of six cells; the results of one only, however, are tabulated; this cell had been charged to its full capacity in each case. Nevertheless, Table I. shows a useful capacity of only 137·28 ampère-hours, against 156·38 ampère-hours in Table II. At the high rate of discharge the current falls gradually, in fact it is not constant for more than three-quarters of an hour throughout the experiment; the E.M.F. likewise falls with the current, though not in the same ratio. This result indicates that the battery has been discharged at too high a rate; the combination of the gases could not take place with sufficient rapidity, and some of the energy had to be sacrificed. There are, nevertheless, numerous instances where such variations may be almost imperceptible, but where a high rate of discharge is much desired; this is the case with electric cars, boats, and the like. In Table II. the discharge is practically constant.

On further examination we find that the initial E.M.F. in Tables I. and II. is 2·14 volts; this lasted only a few minutes, nevertheless, it ought to be taken into account when ascertaining the *average* E.M.F. The current, again, in Table I. drops suddenly from 55·64 to 46·65; this is only partially due to the drop of E.M.F., and mainly to the fact that iron tape was used as an external resistance, which got very hot in a short time; as the resistance rose with the temperature, so the current diminished. This variation is not so marked in Table II., where the current drops from 23·97 to 22·56 in the first half-hour; the same section of iron tape was used in this case, but of a length to give nearly double the resistance, and therefore about half the current.

In calculating the percentage of fall of current and of E.M.F. throughout an experiment, we ought not to take the first reading as the highest, but the second reading; because the initial effect is of little value and of but short duration. Taking the second and the last readings into account, we find that the fall of E.M.F. in Table I. is ·17 volt, or 8·33 per cent.; the fall of current is 5·99 ampères, or 12·83 per cent. In Table II. the differences are much less as a natural consequence of the lower rate of working; there the drop of E.M.F. is only 6·86 per cent., and of the current, 8·15 per cent. between the second and the last readings. With an average discharge of 45·76 ampères the current drops 12·83 per cent. in $2\frac{3}{4}$ hours, the external resistance being practically constant; by discharging the same accumulator at the average rate of 22·34 ampères, the current falls only 8·15 per cent. in $6\frac{3}{4}$ hours. This points to the well-known fact that a secondary battery must be discharged at a comparatively low rate if its current or E.M.F. is to be kept constant without altering the external resistance or altering the number of cells in circuit. In practice, it will be found that the most economical *current rate* is that which discharges a given accumulator in 10 hours; this holds good for stationary accumulators (*b*), but for the locomotive type (*a*) we can exceed this rate considerably without sacrificing efficiency.

Energy.—The energy given off by a storage battery is the product of the current and the E.M.F., and the *rate* at which energy is being given off is expressed in watts.

Reverting to Table I., the rate at which energy is being consumed at 10 a.m. is 95 watts, whereas at 12.45 p.m. it falls to 76 watts. The *average rate*, however, is 45·76 ampères × 1·964 volts = 89·87 watts; and this represents ·12047 electrical H.P. or 3,975·51 foot pounds. The *total* energy given off by this accumulator in the course of three hours was 3,975·51 × 3 × 60 = 715,591·8 foot pounds; therefore one cell of 137·28 ampère hours useful capacity, working at the above average current rate and E.M.F., will yield ·12047 H.P. for three hours.

In Table II. the same cell gave 44·68 watts, or ·06 H.P. for 7 hours, which represents 831,600 foot pounds, a gain of 116,008 foot pounds over that in Table I.; this again shows the advantage of a low rate of discharge; the loss of energy through the rapid rate of working approaches 14 per cent.

Relation of stored energy to quantity of active material.—The available amount of *energy* is of greater importance than the capacity of a storage battery; the one expresses the actual work done, whereas the other merely gives the current and the time. We have already seen that the available energy of an accumulator varies with the rate of working, consequently the relation between energy and quantity of material must also change according to circumstances. We have on a former occasion ascertained that the total weight of peroxide and spongy lead in the cell (*a*) for locomotive purposes is 11·5 lbs. We have also calculated that this cell, when discharged at the rate of 45·76 ampères, will yield a total energy of 715,591·8 foot pounds; hence in this case each pound weight of active material gave $\frac{715,591·8}{11·5}$ = 62,225 foot pounds. Whilst discharging at the rate of 22·34 ampères the "output" was 831,600 foot pounds, or 72,313 foot pounds per pound weight of active substance; this is equivalent to 2·19 horse-power per minute per pound of material.

Intermittent discharge.—If we interrupt the process of discharging and allow the plates a moment's rest, then we obtain on rejoining the circuit an E.M.F. and current slightly above that which was observed just before the interruption. By such intermittent discharges it is possible to obtain tolerably regular results even at very high current rates. The gases have time to arrange themselves, whilst the liquid obtains access into the pores of the plates. An accumulator is just like a horse; if you give the horse its regular easy work to do, then he will go along at a constant rate all day long; give him too great a load, then he will gradually lose in speed until he comes almost to a standstill; allow him to "blow" for a quarter of an hour occasionally and he will get along with the great load at a good rate during the regular intervals. But if we take the time as well as the energy into consideration, then we find that the steady easy work will turn out more efficient than the great exertion with intermittent rest. Efficiency, however, does not always mean economy, and there are numerous cases where a small secondary battery worked at a high rate is far more economical than the more efficient larger apparatus working under its normal conditions. The efficiency in *ampère hours*, for instance, yielded during the experiment of Table I. was barely 79 per cent., whereas that of Table II. is nearly 90 per cent. But in the one case the energy is diffused in the short space of three hours and in the other in seven hours; and the rate of energy given off in Table I. is twice as great for the same weight as in Table I.

(*To be continued.*)

Electrical Experiments.—An interesting display of the numerous applications of electricity was shown last week at the annual *conversazione* of the Birmingham and Midland Institute, the current for the purpose having been supplied from 26 storage cells lent by Messrs. Elwell-Parker & Co. The principal experiment was with the voltaic arc. By means of a lens the image of the heated carbons was projected on the screen, and the boiling action of the carbons, together with the light of the arc, which was changed from one colour to another by the introduction of small pieces of copper, brass, thallium, and other metals, was very plainly seen. Illustrations of the resistance of metals was shown in the usual manner, and an apparatus for separating steam into its constituent elements, due to Mr. Justice Grove, was also on exhibition.

ELECTRIC LIGHTING OF THE COLONIAL AND INDIAN EXHIBITION.

The following report has been issued by the Electric Lighting Committee, which consisted of Sir Frederick Abel, C.B., F.R.S., D.C.L. (Chairman), Col. Sir Francis Bolton, and Mr. W. H. Preece, F.R.S., with Mr. J. H. Cundall as Engineer and Acting Secretary, and Mr. G. Schultz as Technical Assistant, upon the internal lighting, the garden illumination, and the fountain display, at the recent Colonial and Indian Exhibition.*

THE INTERNAL ELECTRIC LIGHTING.

THE internal lighting of the Exhibition buildings has been carried out in accordance with the scheme submitted by the Electric Lighting Committee to the Secretary on November 10th, 1885, and approved by His Royal Highness the Prince of Wales.

The expenditure has amounted to £14,523 2s. 2d. (exclusive of salaries of staff and office expenses, and the plant taken over from the International Inventions Exhibition).

The following is an account of the arrangements made, and results obtained, by contracting companies, in carrying out their respective agreements :—

Messrs. Davey, Paxman & Co., the contractors for the motive power, have used for the purpose twelve boilers and seven engines, of the following nature :—

Seven boilers of the locomotive type, 16 feet long by 4 feet 6 inches diameter, with fire-grates having 16 square feet area, and a total heating surface of 610 square feet, and working at a pressure of 100 lbs. per square inch. Four boilers of the same dimensions, but working at a pressure of 120 lbs. per square inch. A boiler 18 feet 6 inches by 4 feet 6 inches diameter, with a fire-grate area of 19½ square feet, and a total heating surface of 711 square feet, and working at 110 lbs. pressure, beneath which was :

No. 1. A compound engine with a high-pressure cylinder 12¼ inches diameter, and a low-pressure cylinder 20 inches diameter, by 2 feet stroke, and giving about 110 horse-power. This engine has been used every day and evening for driving machines charging secondary batteries.

No. 2. A pair of high-pressure coupled horizontal engines with cylinders 18½ inches by 32 inch stroke, worked at 100 lbs. pressure, and giving about 264 horse-power.

No. 3. A compound engine known as the "Girder Type," with high-pressure cylinder 11½ inches diameter, low-pressure cylinder 20 inches diameter, and 2 feet stroke, giving about 96 horse-power.

No. 4. A compound horizontal engine, with high-pressure cylinder 15 inches diameter, low-pressure cylinder 22½ inches and 2 feet stroke, working at 120 lbs. pressure and giving about 142 horse-power.

No. 5. A compound horizontal engine, with high-pressure cylinder 8¼ inches diameter, low-pressure 14¼ inches by 14¼ inches stroke, working at a pressure of 120 lbs.

No. 6. A pair of horizontal high-pressure engines coupled, with cylinders 19 inches diameter 32 inches stroke, working at 100 lbs. pressure, and giving about 265 horse-power.

No. 7. A vertical compound engine with high-pressure cylinder 9¼ inches diameter, low-pressure 16 inches by 12 inches stroke, working at a pressure of 120 lbs., and making 110 revolutions per minute.

Engine No. 5 drove one Crompton and one Pilsen dynamo machine, direct. No. 7 drove one large Brush dynamo machine direct ; the remainder of the engines each drove a line of counter-shafting, making 230 revolutions per minute, from which power was taken for the machines. The total average run by each engine was about 585 hours, and the whole plant worked generally in a satisfactory manner.

Twelve hundred horse-power was stipulated for in the agreement, but about 1,000 horse-power has been found to be sufficient to meet the requirements, and for this service Messrs. Davey, Paxman & Co. have been paid the full stipulated amount under their contract, £4,600, besides £83 5s. for extra power used in charging secondary batteries. The basis of the contract was at the rate of payment of 1½d. per horse-power per hour.

The Anglo-American Brush Electric Light Corporation, Limited, have, in accordance with their contract, worked 160 arc lamps, arranged in six circuits, for 596·25 hours ; the minimum number of 600 hours lighting mentioned in the contract has therefore not been quite reached. In addition to the foregoing a circuit of ten arc lamps, which were provided at a later date, have been alight 483 hours. The lamps used required each an electromotive force of 50 volts, and a current of 10 ampères, absorbing a total of 85,000 watts. The whole installation worked regularly and well. Fines for lamps not burning when required, amounting only to £1 15s. 8d., have been imposed in accordance with the terms specified in the several contracts for the internal lighting ; the total sum paid to this company by the Royal Commission was £2,112 9s. 3d.

Messrs. R. E. Crompton & Co. have worked 140 arc lamps, arranged in ten circuits, for 578 hours, the electromotive force of each lamp being 50 volts, with a current of about 14·5 ampères, absorbing a total of 101,500 watts. The installation of this company was very unsatisfactory for the first six weeks after the opening of the Exhibition, owing to causes and mishaps unforeseen by the contractors ; it afterwards worked with comparative steadiness, the light given by the lamps being greater than that of the other companies. Fines to the amount of £150 1s. 2d. have been imposed upon the contractors, and the total sum paid has been £1,679 18s. 10d.

The Pilsen-Joel and General Electric Light Company, Limited, have had 113 lamps in work for a total of 593 hours. These lamps have been very steady and satisfactory ; they were arranged in six circuits, the electromotive force of the lamps being 48 volts, with a current of 9·5 ampères, absorbing a total of 51,528 watts. Fines to the amount of £2 13s. 2d. have been imposed, and the total payment to the contractors has been £1,380 17s. 10d.

The total area of the galleries illuminated by the three companies was about 480,000 square feet, for which 388 arc lamps have been used (the remaining 35 lamps being placed in the grounds and in buildings not included in the exhibition galleries). The average cost of illumination has been about sixpence per square foot of floor area, for a period of about 600 hours. The electrical measurements showed an average energy of 220,410 watts, giving ·43 watt per square foot of floor area, or 2·3 square feet of floor area per watt.

Incandescent lamps were used for lighting those portions of the exhibition buildings and offices where arc lamps could not, on account of their high power, have been used. About 1,851 lamps of 16 candle-power each were distributed according to the list given in the appendix. The whole were installed and worked by the staff of the Royal Commission.

The Colonial Commissioners and certain exhibitors have been supplied with 132 of the above lamps for their private use, for which a rental of £198 has been charged, being at the rate of 30s. per lamp. The refreshment contractors were also charged £100 as a contribution to the cost of lighting the South Dining Rooms, and £50 for lighting their two cellars.

For supplying the current to these incandescent lamps six Edison-Hopkinson dynamo machines have been used, viz., three 32-kilowatt machines and three 16-kilowatt machines ; a seventh 32-kilowatt machine of the same make was used for charging secondary batteries, and one additional machine was held in reserve in case of accident.

These eight machines were lent by the Edison-Swan United Electric Lighting Company at a rental of £225 for the period of the exhibition, the Royal Commission finding attendants, and having the machines entirely

* Since deceased.—EDS. ELEC. REV.

under their control; the machines have given very satisfactory results. An additional 40-kilowatt dynamo machine was also hired from Messrs. Elwell-Parker for charging the secondary batteries; for this machine a rental of £80 was paid.

The Electrical Power Storage Company, Limited, lent on hire two storage batteries, at a rental of £400. One battery, composed of 208 cells, supplied current to the 320 lamps in the Quadrant Dining Rooms, the average charge being 1,144 ampère-hours, and the discharge 820 ampère-hours. The second battery, composed of 216 cells, supplied current to the 242 lamps distributed in the Railway Subway, the refreshment contractor's two cellars, and the executive offices.

The committee are glad to be able to report that no accident has occurred during the whole period of working, nor have there been any but trifling local interruptions of the light for brief periods; moreover, there has not been even an alarm of fire in any one of the departments of the building. The report of the electrical inspector of the committee of the fire offices, which is appended, shows that the work has in all respects been thoroughly and efficiently carried out.

Detailed technical reports are attached, giving full information relative to the working of the whole installation.

THE GARDEN ILLUMINATION.

The garden illumination has been carried out by Messrs. Galloway and Sons according to the terms of their contract, on the basis of the scheme drawn up by Sir Francis Bolton, which was submitted to the secrecretary by the lighting committee, on December 15th, 1885, and was approved by his Royal Highness the Prince of Wales. For the purpose of this contract Messrs. Galloway erected a pair of compound horizontal engines, having 15-inch high-pressure and 26-inch low-pressure cylinders, with a 30-inch stroke; the two engines together developed about 187 horse-power as generally worked, but either one was quite equal to performing more than the whole work, should the necessity have arisen. The steam for these engines was obtained from four Galloway boilers, three only being in use at one time; the boilers were 26 feet long by 6·5 feet diameter, and were worked at a pressure of 80 lbs. per square inch.

Four Elwell-Parker compound-wound 50-kilowatt (nominal) dynamo machines were used, with an average total electromotive force of 180 volts, and a current of 540 ampères collectively; any two of these machines could, when desired, have supplied the current required for the whole installation.

The lamp circuits, twenty-three in number, were so arranged that the lamps were placed in series of eight. The total number of incandescent lamps in use at the commencement of the exhibition was 9,624. This number was subsequently reduced by order of the committee to 8,584; it comprised 8,034 5-candle-power, 414 10-candle-power, and 136 20-candle-power lamps.

In addition to the incandescent lamps, 18 arc lamps of the Brush type were placed on three iron masts. These lamps were fed by a Brush machine, driven by a Galloway engine similar to those described above, and placed in the West Quadrant, the same engine being used for driving the dynamo for the fountain lamps. The total number of hours' working was, for the incandescent lamp installation 376 hours, and for the arc lamps 403½ hours.

The Royal Commission, having purchased the whole plant used by Messrs. Siemens Brothers for the garden illumination during the International Inventions Exhibition, for £5,460, transferred it to Messrs. Galloway at the same price. These machines and engines were held as a reserve in case of a serious accident, but were only used on a few occasions.

The contract price for carrying out the work amounted to £9,670, including the purchase of the Siemens installation. To this were added the sum of £126 17s. 6d. for lamps broken by the public, and a further sum of £300 for expenses incurred in preparing the installation, beyond £2,000 provided for this purpose in the contract.

The committee are pleased to have to report that the working of this large installation has been carried out in a thoroughly satisfactory manner, that but very few slight interruptions to the lighting have occurred, and that no damage to person, property, or accident has happened; the performances of the engines and dynamos were very creditable to their respective manufacturers.

THE FOUNTAINS.

The fountains in the gardens of the exhibition have, like the garden illuminations, been carried out under contract by Messrs. Galloway and Sons, in accordance with a scheme prepared by Sir Francis Bolton, which was submitted by the lighting committee to the secretary on February 3rd, and was approved by his Royal Highness the Prince of Wales.

The fountains, as used at the previous exhibition, received considerable alteration and additions; the room under the island was very much enlarged, and more jets for the discharge of water were added. As arranged for this year's exhibition, there were, besides one large centre jet, three concentric rings of jets and sprays surrounding this, there being in all 103 jets, besides one ring forming a spray. The whole were controllable separately or in groups by valves placed in the room in the island.

In addition to the water, a curtain or ring of steam was occasionally thrown up; this was conducted in pipes to the interior of the island from boilers placed outside the West Quadrant.

For the illumination of the jets of water, 16 electric arc lamps of a high candle-power, and regulated by hand, were placed under and in the line of discharge of each of the chief jets. These lamps were provided with powerful lenses and reflectors; they were arranged in parallels of four, the four groups being in series. The approximate current was 200 ampères and 210 volts; it was supplied by a Victoria dynamo, manufactured by the Anglo-American Brush Corporation, which was driven by the engine in the West Quadrant.

There were during the period of the exhibition 267 displays of the fountains, amounting to 133½ hours. Of these 212 displays, amounting to 106 hours, were in the evening, and were illuminated; the remainder being on Wednesday and Saturday afternoons. The total amount of water used was 12,877,500 gallons.

The total sum paid to the contractors by the Royal Commission was £1,973 10s. 10d., which included a sum of £66 13s. 4d. for the extra nine days the exhibition remained open in November.

The contract was carried out in a most satisfactory manner; no interruption nor accident of any kind having occurred; and the results obtained fully realised the effects designed to be attained.

F. A. ABEL.

Chairman of the Electric Lighting Committee.

December 20th, 1886.

DETAILED TECHNICAL REPORTS.

(*Submitted to the Committee by J. H. Cundall and G. Schultz.*)

I.—INCANDESCENT LIGHTING.

For certain portions of the exhibition, such as the dining rooms, refreshment rooms, Old London, the Indian Palace, Hong Kong Pavilion, subway, and cellars, 1,851 incandescent lamps have been used, the current to which was supplied by four large 32-kilowatt and four 16-kilowatt machines, manufactured by the Edison-Swan Electric Light Company.

Of these eight machines three 32-kilowatt and three 16-kilowatt machines were used to drive the lights direct, and were connected to an exchange switch-board. They were fitted with extra variable resistances in their shunt circuits, which were connected to a six-way

switch, and by that means to a voltmeter, to enable the attendant to raise or lower the electromotive force of the different circuits as required, in case of variation of speed, this precaution being found necessary. Two machines were held in reserve in case of a break down, but their services were not required.

One large 32-kilowatt machine was used to charge 216 accumulator boxes in the Subway Accumulator House.

Of these eight machines there is no failure to record. Their work has been entirely satisfactory, and has fulfilled all expectations.

A four-pole 40-kilowatt dynamo machine, supplied by Messrs. Elwell Parker & Co., was used for charging another set of accumulators in the West Quadrant. The armature of this machine had to be returned to the makers twice in July, owing to defective insulation between the sections of the commutator. Since then it has worked satisfactorily.

The Electric Light and Power Storage Company, Limited, lent two sets of accumulators.

Set No. 1 was placed on four stands in the Quadrant, and supplied the current for 314 46-volt lamps, run two in series.

This battery consisted of 208 31-L type accumulators, arranged in two sets of 52 series of two cells in parallel, the terminals of the two sets being joined in parallel so as to form one battery. The approximate charge of this set per day has been from 192 to 200 ampères for about seven hours = 1,200 to 1,400 ampère hours daily; and the discharge has been about 162 ampères for five hours = 860 ampère hours.

The fall of electromotive force during five hours' discharge was as follows :—

For the 1st hour 2 volt.
„ 2nd „ 1 „
„ 3rd „ 1 „
„ 4th „ 1 „
„ 5th „ 1 „

Total 6 volts for five hours' discharge.

This battery was supposed to be capable of discharging 240 ampères at 100 volts, but was only discharged at the rate of 169 ampères and 96 volts when full on.

There was a great deal of scale adhering to the plates, but no serious failure took place.

Set No. II. was placed on four wooden stands in a house specially built for the purpose at the upper end of the South Promenade; it was used during the day as a regulator to the circuit from the machine to the lamps, and, for two hours daily, to take up the work when the engine and dynamo stopped. The lamps run on this circuit consisted of 64 80-volt and 18 100-volt lamps in the subway, 102 50-volt lamps in the cellars, and 55 100-volt lamps in the offices. The battery consisted of 216 cells, 208 of which were 31-plate R type, and eight 31-L type. These cells were arranged in two sets of 54 series of two cells in parallel, the terminals of the two sets being joined in parallel so as to form one battery.

The approximate daily charge of this battery has been about 105 ampères to 107 ampères for 10 hours = 1,050 ampère hours, and the discharge has been from 137 to 140, and for three hours = 411 to 420 ampère hours.

About the middle of August a serious drop of electromotive force was noticed. The Electric Power Storage Company having been communicated with, found it necessary to change eight sets of plates, as they had suffered severely from buckling.

Wire.

All wire used in the whole of the installation had been in use during the previous exhibitions; but the "wiring" was all freshly installed this year, as far as practicable according to the rules of the Phœnix Fire Office.

The average insulation resistance was :—

Arc leads, on a fine dry day, 450,000 ohms.
„ on a wet day, 300,000 ohms.
Incandescent leads, on a fine dry day, 25,000 ohms.
„ on a wet day, 18,000 to 2,600 ohms.
Total length of arc leads, 28,300 yards.
„ Incandescent leads, 16,235 yards.

Incandescent Lamps.

The 1,851 incandescent lamps consisted of 416 new lamps supplied this year by the Edison-Swan Company, in addition to lamps of various makers taken over from previous exhibitions. The figures in Appendix B. show that the Edison-Swan new lamps were not nearly so long lived as those supplied and manufactured in previous years.

Attention may be drawn to the fact that the old 96-volt Edison lamps show the longest lives, the electrical failures being very low. The same may be said of the 100-volt Woodhouse and Rawson lamps.

The lighting by incandescent lamps was distributed in seven sections, as follows :—

No. I. consisted of 436 96-volt lamps, driven by a 32-kilowatt Edison-Hopkinson dynamo, and distributed in the following buildings :—

Vestibule	114	436 lamps.
Colonial Tea Pavilions ...	67	
Indian Palace	211	
Kitchens	17	
Offices	27	

No. II. consisted of 96 48-volt lamps, run two in series, driven by a 16-kilowatt Edison-Hopkinson dynamo, and lighted the Indian Tea Gardens.

No. III. consisted of 284 60-volt lamps, run in parallel, driven by two 16-kilowatt Edison-Hopkinson dynamos, and distributed in the following rooms :—

Spiers and Pond's à la Carte Dining Rooms.
„ „ First Dining Rooms.
„ „ Buffet.

No. IV. consisted of 189 100-volt lamps in parallel, and 64 50-volt lamps, two in series, driven by a large 32-kilowatt Edison-Hopkinson dynamo, and distributed as follows :—

Old London	116	252 lamps.
Exhibitors in Australian and Cape Courts	82	
Ceylon Tea House	40	
Grill Room and Offices ...	14	

No. V. consisted of 314 46-volt lamps, two in series, run off the Quadrant batteries, lighting the Quadrant Dining and Temperance Rooms.

No. VI. consisted of 212 96-volt lamps, driven by a 32-kilowatt Edison-Hopkinson machine, and lighting the

Chinese Pavilion	171	212 lamps.
Exhibitors' Stands	29	
Prince of Wales' Box ...	12	

No. VII. consisted of 83 80-volt lamps, 102 50-volt lamps, and 75 100-volt lamps, supplied by a 32-kilowatt dynamo and accumulators, and were distributed as follows :—

Subway	91	248 lamps.
Cellars	102	
Offices	55	

(*To be continued.*)

SECONDARY BATTERY PATENTS.

WE find that the specification of Mr. J. S. Sellon, to which he refers this week in our Correspondence columns, is out of print. For the benefit of our readers, therefore, we reproduce the exact text of a copy in our possession, the provisional of which, in almost identical words, is dated December 23rd, 1881, together

with clauses from the patents of Messrs. FitzGerald and Jones bearing upon the point at issue :—

Specification in pursuance of the conditions of the Letters Patent filed by the said John Scudamore Sellon in the Great Seal Patent Office on the 23rd June, 1882.

John Scudamore Sellon, of Hatton Garden, in the County of Middlesex, "Improvements in the construction of secondary batteries."

My invention relates to the construction of the terminal plates, supports, retainers or frames upon and in which the active material or agent is deposited, placed or fixed.

In carrying out my invention I construct such plates, supports, retainers or frames of a material or materials not readily subjected to the destructive influence of oxidation or other destructive action, such, for example, as carbon, either in a solid form or compressed or mixed, or amalgamated with other substances, or as asbestos, wood, papier maché, cellulose, either alone or in combination with metals not easily oxidised, such, for example, as platinum. The plates, supports, retainers or frames composed of one or more of these materials are constructed in the following or other suitable form or forms.

For example, they may be made of a cellular, perforated, corrugated, grooved, fluted, roughened, indented, tubular or woven shape, or any combination of these forms, or of any other shape capable of retaining the active material or agent in a finely-divided pasty, deposited, compressed or other condition; I may make the plates, supports, retainers or frames of a compound form, say, for example, two outer non-metallic plates constructed in the manner hereinbefore described, with an intervening plate, film or coating of metal, such, for example, as platinum, such combination forming a terminal; or I may cover either mechanically or by means of electric deposition or otherwise either the single or compound plates with a layer or film of metallic matter, such, for example, as platinum.

Having now described and particularly ascertained the nature of my said invention and the manner in which the same is or may be used or carried into effect, I would observe, in conclusion, that what I consider to be novel and original, and therefore claim as the invention secured to me by the hereinbefore in part recited letters patent is :—

The construction of terminal plates, supports, retainers or frames employed in secondary batteries of a material or materials not readily subjected to the destructive influence of oxidation in the manner and for the purposes herein described.

In witness whereof I, the said John Scudamore Sellon, have to this my specification set my hand and seal this 21st day of June, 1882.

JOHN S. SELLON (L.S.)

The following is the 6th claim of Desmond G. FitzGerald and T. J. Jones in their specification dated 29th November, 1884 :—

6th. In the construction of negative elements for voltaic batteries, the combination of a perforated or apertured support of non-conducting material and of a pasty mass susceptible of being converted into peroxide of lead by electrolysis, which mass is filled into the apertures and thereby held against the surface or surfaces of the said support, substantially as specified.

DESMOND G. FITZGERALD.
T. J. JONES.

Finally we come to the six claims in the patent granted to T. J. Jones, dated 23rd April, 1885, which run as follows :—

Having now particularly described and ascertained the nature of the said invention, and in what manner the same is to be performed, I declare that what I claim is :—

1. In a voltaic battery, a support for the active material constructed entirely of an inoxidisable material such as gutta-percha, India rubber celluloid, xylonite (or compounds containing these or equivalent substances), and coated wholly or partially with gold or platinum foil, substantially in the manner and for the purpose specified.

2. In a voltaic battery, a support for the active material which is inoxidisable and yet conductive, consisting of fragments or particles of hard carbon in electrical contact with one another, and of an inoxidisable substance, such as herein mentioned, which serves to hold the carbon fragments or particles together and protect them from the effect of electrolysis, substantially as specified.

3. In a voltaic battery, a support for the active material which is inoxidisable and yet conductive, consisting of fragments or particles of hard carbon in electrical contact with one another and of a sufficient quantity of celluloid or compounds thereof to protect and hold the carbon fragments or particles together.

4. In a voltaic battery, a support for the active material which is inoxidisable and yet conductive, consisting of fragments or particles of hard carbon in electrical contact with one another and held together and protected from electrolytical action by an inoxidisable substance, such as herein mentioned, in combination with a layer of gold or platinum applied upon exposed portions of the carbon for the purpose of further protecting the latter and effecting electrical contact between the carbon and the active material, substantially as specified.

5. The combination, with the elements of a voltaic battery, of contact pieces, strips, terminals or their equivalent, composed of an inoxidisable substance, such as herein specified, coated wholly or partially with platinum or gold and applied against the active material substantially as specified.

6. The combination, with the elements of a voltaic battery, of contact pieces, strips, terminals or their equivalent, composed of an inoxidisable substance and carbon fragments or particles and applied against the active material, substantially as specified.

Dated this 16th day of June, 1885.

T. J. JONES.

ELECTRIC WELDING.

By PROF. ELIHU THOMSON.

THE energy of the electrical current at any time at our disposal may be utilised to produce motion in its various forms, such as mass motion, as in electric motors, driving machinery, or propelling a train, ; wave motion, as in telephonic sounds; light or luminous wave motion, as in electric lamps; chemical decompositions, as in electro-plating; and heat motion, which latter nearly always attends the conversions just alluded to as a waste or loss, more or less unavoidable.

Whilst I do not share in the anticipations of some over sanguine people, that the energy of electricity will be used when directly converted into heat for warming our buildings, still we have ample evidence of the fact that for special purposes heat so produced can not only be applied practically but economically. Electric heating is perfectly applicable to cases in which the supply of needed heat is small and requires to be kept up for a prolonged period under perfect control, or in which a sudden, quick heating of moderate amount is to be used. Again, if the temperature required to effect a given operation is above that producible by combustion, electricity may be employed; for the temperature producible by its means is only limited by the vaporisation and expansion of the materials heated. We find an instance in the Cowles electric furnace, used for the reduction of those metallic oxides which even in the presence of carbon will not at ordinary furnace temperatures part with their oxygen, but which in the electric furnaces are subjected to temperatures very near that of the vaporisation of carbon, or that of the fusion of the oxides and consequent intermingling of their particles intimately with those of carbon.

It is my purpose in the present paper to give an account of a new way of utilising the heating effects of heavy electrical currents, for uniting or causing union between pieces of metal, whether of the same or of different kinds. I have called the process "Electric Welding."

Hitherto the metals which have been welded with facility by the ordinary methods of furnace heating and subsequent hammering have been wrought or soft iron, steel, platinum, pure gold and a few others. So far as I know, cast iron, brass, gun metal and bronze, German silver, zinc, tin, lead, aluminium and other metals and alloys more or less commonly used, have not hitherto been welded, and even in the case of copper, which softens readily by heat, the welding together of two pieces, though not impracticable, has been so difficult as to have been seldom tried with success. Much less, indeed, has it been generally practicable to weld pieces of unlike metals together; and even with iron, very small pieces can scarcely be welded in the ordinary way on account of the rapidity with which the heat is dissipated, thus reducing the temperature below the welding heat.

All this, however, is changed when we come to the practice of electric welding. Some of the metals which it was before impossible to weld become those most easily dealt with. Such are cast iron, brass, bronze, zinc, tin, &c. Copper, formerly welded with so great difficulty and uncertainty, becomes remarkable for the facility with which joints are made when the proper temperature is reached. Iron, steel, platinum and like

metals, formerly known as weldable, are united electrically with great ease and certainty. Thus far pieces of all the metals tried have welded to other pieces of the same metal. When, however, the pieces are of different metals or alloys, failure may result from too great differences, either in their temperatures of softening or in their specific electrical and heat conductivities.

The method of electric welding may be briefly stated to consist in forcibly pressing together the bars or other pieces to be joined or welded, and then passing an electric current of large volume through the pieces, a small portion of the bars on each side of the place of abutment serving as a path for the current. The resistance at the meeting point of the abutted bars gives rise to a welding heat at this point, and the pressure causes a thorough union, with generally an expansion at the union due to the approach of the pieces under pressure. The process is evidently a simple one.

Now let us inquire what are the results and the possible uses of electric welding? An enumeration of some of them may be of interest.

One of the most evident applications is in joining, end to end, wires of copper and iron for various purposes, such as in forming coils of magnets, and in telegraph, telephone and electric light line construction, thus avoiding the existence of clumsy and resisting joints.

In the factory of the Thomson-Houston Electric Company, wires have been so joined in the practical construction of dynamos, and the method will be extended in use there as soon as the necessary apparatus can be built.

I have specimen wires of copper and iron of varying sizes with electrically welded joints, some of which wires have been bent and twisted without rupturing the weld. There is no reason why very heavy bars may not be operated upon by using sufficiently large and powerful apparatus. The largest diameter of copper rod thus far welded measures nearly $\frac{1}{16}$th inch, and of steel nearly $\frac{7}{8}$th inch in diameter, and so far as can be determined by estimation alone, this required a current of over 20,000 ampères. This is probably a much larger current than has heretofore been produced in any single conductor or machine. The difference between the sizes of iron and copper welded by equal currents is due to the smaller resistance of the copper and the greater facility with which it conducts heat away from the junction during the operation. The specimens which I have comprise a variety of sizes and shapes of iron, steel, copper and other bars, in some of which the expansion at the weld remains as formed, and in others it has been ground off or removed, to show the character of the metal at the weld.

Another obvious use of the new welding process is in the butt welding of metal tubes or pipes, examples of which are iron pipes of various diameters, brass and copper tubes joined end to end, and a lead pipe with two joints, which pipe has, as a test of complete union, been much bent after the formation of the joints. The joints on the iron pipes have in most cases been hammered during, or just after, the welding, and are very firm and strong. It is quite possible to make long lengths of cast iron or wrought iron pipe for street service, which may be laid with few caulked, cemented or screw joints, or, even as a completely welded, unbroken pipe, bends being made at intervals to allow for expansion during change of temperature. For high pressures of steam, air, or gas, such a system would seem to be desirable. Long iron pipes are now very laboriously made from short lengths for bending into coils containing from 100 to 1,000 feet. The electric weld would render such an operation easy.

In making or repairing endless bands, such as band saws, wheel tires, barrel and tank hoops, the electric method promises to be of great utility, some specimens of such work having been produced. Analogous to this is the heating and welding of iron and steel links of various kinds.

Besides the application of electric welding to uniting together bars and pieces of various metals, of various sections and of various shapes, as briefly outlined above, there is a very wide field of usefulness to be found in the manufacture and repair of tools and parts of machinery. In the factory of the Thomson-Houston Electric Company at Lynn, there are in use a number of tools having electric welds, and it is intended also to extend the welding to the construction of other tools to which it is applicable with a saving of cost.

As examples of such work, I may mention the lengthening of screw taps, drills, reamers, augers, to any amount required; mending chisels and punches when worn out or broken, by providing them with new edges welded to the old bodies; lengthening screw bolts by welding sections of bar between the screw and the head of the bolt, or shortening them by cutting out sections and reuniting the head and the body; welding new drills and reamers to the taper shanks of old and worn out drills and reamers; renewing the points of worn out centres for lathes; renewing the cutting ends of lathe turning tools when worn out or broken, instead of casting the steel aside as useless; uniting short pieces of shafting into longer lengths; reuniting the pieces of broken tools; and, in general, welding steel pieces to steel or wrought iron or even to cast iron bodies of tools. One quality of steel may be used for the cutting edges and another for the body of the tool. There are, without doubt, many instances in which the construction of tools used in the various trades may be cheapened by joining together pieces to form such tools as would otherwise have been cut or forged from one piece of metal.

Electric welding is applicable to the very delicate work of the jeweller's art, and equally so to the joining of the parts of heavy machinery. I have united the ends of wires less than $\frac{2}{100}$ths of an inch in diameter, and the size of the larger pieces dealt with has only been limited by the power of the apparatus at command.

I have reason to think that the actual fuel consumed in effecting a weld by electricity, notwithstanding the loss in boiler, engine and electrical apparatus used, is less than in the ordinary blacksmith's processes, and chiefly because of the very small time needed to effect the electric junction, as well as to the application of the heat to the metal locally at and near the weld, with the consequent small losses by radiation and conduction. Besides this, the time required is so short that quite a number of joints may be formed in the time ordinarily required to make one, and the pieces are not required to be skilfully manipulated during the process—a great advantage in the working of large pieces.

Having thus rapidly reviewed the possible applications, as they now present themselves, let us turn to the operation itself.

In the first place, electrical current energy is a product of its pressure or electromotive force by its amount of flow or volume. Hence, to represent a certain amount of energy, we can have a small volume of current with a high electromotive force or pressure, or a very large current with a very small electromotive force, just as we may have a small flow of water at a great head or pressure fed to a turbine, and yield, say, a horse-power, while the same power may equally be yielded by a much larger flow of water under a small pressure or head, with a suitable wheel. Or, electrically speaking, a flow of current of one ampère, with an E.M.F. of 746 volts, represents energy at the rate of one horse-power, or 33,000 foot pounds per minute, and the same energy is represented by a flow of 746 ampères with one volt, or 1,492 ampères with half volt, In arc lighting, ordinarily, a current of 10 ampères and 2,500 volts E.M.F. is not infrequently used. In incandescent lighting in multiple arc, 250 ampères and 100 volts would represent an equal energy, and in electric welding 50,000 ampères and half a volt would be the equivalent; and this would probably weld a bar of steel $1\frac{1}{2}$ inches in diameter, as nearly as I can now estimate the conditions. But there is quite a difference between running electric lights and welding. The lights demand the power continuously, while in welding the energy is demanded for a comparatively short

time, varying from a few seconds to half a minute or more, according to the size of the piece. If my estimates are anywhere near correct, it would require to weld a bar of steel 1½ inches in diameter, an expenditure of about 35 horse-power for less than a minute.

The apparatus used in generating and applying the currents for electric welding will vary according to the character of the work to be done. The chief essentials to be found in it are, outside of the source of current, (1) a means for getting the heavy currents into the pieces without too much waste, such means being solid conducting clamps bound upon each piece; (2) a means for forcing the pieces together during the passage of the current; and (3), a means for holding the pieces in the position desired. The conditions are usually fulfilled by arranging the heavy copper clamps or chucks in line with each other, but at a distance apart which can be adjusted, and arranging a spring and screw for forcing the pieces together. The clamps are connected to the terminals of an electric current producer, such as a very coarse secondary coil of an induction apparatus, the primary of which is supplied with alternating currents from an alternating dynamo; or a cell of a secondary battery of very low resistance and low electromotive force may be substituted for the coil.

small wires of copper, small steel pieces, band saws of small size, &c. The primary coil is put into circuit with an alternating current generator and, together with the iron core, may be inserted or removed from the axis of the secondary coil to a greater or less extent in order to adjust the current to the size of pieces operated upon. The current produced by induction in the secondary coil is of large volume and low electromotive force. The resistance of the secondary coil taken alone is approximately ·00015 ohm.

In another apparatus used by me (shown in perspective and section in figs. 3 and 4) the construction is different, and much larger work can be accomplished with it. The primary coil, P, is simply a large open ring about 12 inches in diameter, 2½ inches wide and ¾ inch or more thick, and is composed of many turns of insulated wire wound on a form. The secondary, S, S, is simply a single heavy bar of copper bent to make only one turn outside the primary coil, and the terminals of the single heavy convolution are bent outward to a parallel position and provided with powerful screw clamps, C, C′, at the ends for holding the pieces, B, B′, to be abutted. The secondary has the form, therefore, of a large copper jew's-harp, with the clamps at the ends of the straight and parallel portions. The clamps are made movable toward and from each other by having

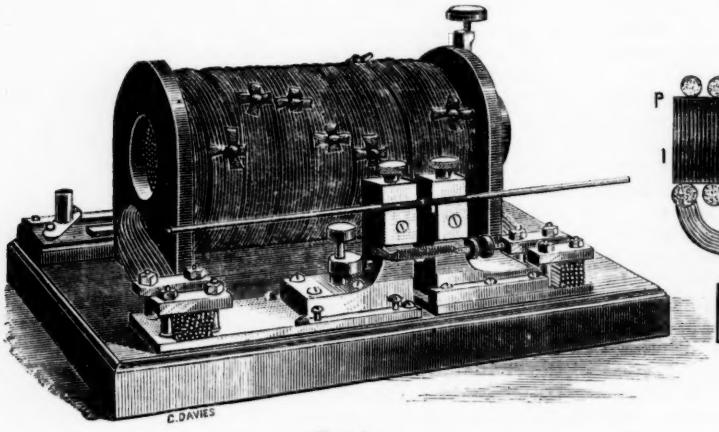

FIG. 1.

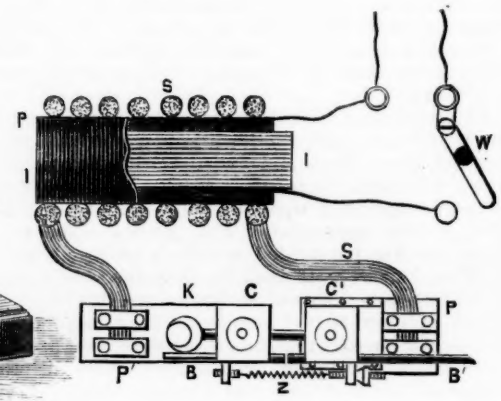

FIG. 2.

DIAGRAM SHOWING ARRANGEMENT OF COIL IN FIG. 1.

One form of the apparatus (shown in perspective and section in figs. 1 and 2) may be described as follows: It consists of an induction coil composed of a core, I, I, of iron wire about 12 inches long and 2½ inches in diameter, around which has been wound a coil of primary wire, P, to be traversed by currents from an alternating current machine. The outside or secondary coil, S, is composed of 64 wires, No. 10 B. and S. gauge, bound together and passing only eight times around the core. The ends of the secondary strand so formed are bolted down to copper plates, P, P′, upon which the clamps, C, C′, for holding the pieces to be welded are mounted. These clamps are formed of comparatively heavy blocks of metal. One of the blocks or clamps, C′, is arranged to slide upon its copper bed plate, and is guided so as to move in a straight line towards the other block, under the action of a spring, Z, which is adjustable. This permits the two pieces, B, B′, held in the clamps for joining, to remain in alignment during the welding, attended, as it is, by a slight movement of the free clamp towards the fixed clamp. A cam, K, is arranged to be turned so as to separate the clamp blocks by forcing back the movable block, C′, and to hold it so during the placing of the pieces in the clamps.

The clamps themselves are simple pieces of metal arranged to be screwed up or down to permit removal of, or to grip, the pieces to be operated upon. The operation of placing the pieces in the clamps in this apparatus requires only a few seconds. This apparatus, as described, is especially adapted to joining the copper bar thinned and broadened at the middle of its curved portion at E, and farthest from the clamps so as to give to the bar a certain degree of flexibility.

The clamps, C, C′, are arranged to be drawn together, when needed, by a powerful screw, J, and spring, *z*, so that the desired pressure for forming the weld may be given; and another screw, K, is provided for forcing the ends bearing the clamps apart, when the pieces are to be inserted in the clamp preparatory to the passage of the current.

Both the primary coil and the secondary bar are wound over with a great mass of iron wire which passes through the open axis of the coils and over the outside of them, thus forming an endless iron core to both the primary and secondary conductors. These conductors are virtually enclosed in a tube or sheath of iron wire. The iron wire, I, I, is in reality wound upon a sheet iron casing or guide, which keeps the wire from bearing upon the secondary bar and interfering with the free movement of the parts of the secondary bar itself, as well as of the clamps. The calculated resistance of the secondary bar is about ·00003 ohm, and under a very energetic primary current it should be capable of generating more than two volts of electromotive force, but it is generally used with much less than maximum excitation. The alternating currents passed through the primary coil, produce, of course, rapid reversals of magnetic polarisation in the iron sheath surrounding the copper conductors, and there results a transfer of energy by

induction to the circuit of the secondary, such transfer being attended with a small percentage of loss. A current of a little over 20 ampères and 600 volts average in the primary may produce in the secondary nearly 1 volt and 12,000 ampères.

For furnishing the alternating currents needed I have designed and constructed a cheap self-exciting alternating current machine, one size of which machine, weighing only 500 lbs., can absorb a maximum of over 25 horse-power at 1,800 revolutions per minute, returning a fair percentage of the power as current for use in welding. The machine has only 10 pounds of wire on its armature and about 40 pounds of wire on the field-magnets. The large output given by this small machine is rendered possible because the machine is called upon to furnish current at intervals only, as during the formation of a joint, and because at other times it runs without load.

Provision must be made by suitable switches to cut off the current from the pieces which are being welded when the weld is seen to be complete. This can be done, of course, by breaking the secondary circuit itself at the proper moment, but it is evident that for such heavy currents the switch would have to be very massive. Equally good results are, however, obtained by cutting off the primary current or by breaking the circuit of the dynamo, or by the shunting or cutting off of current from the field magnets. It is also desirable to provide a means for regulating the power of the currents so as not to suddenly overheat the pieces, especially where

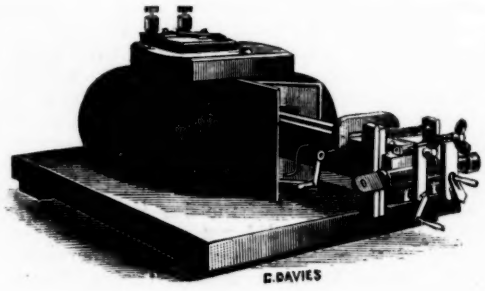

FIG. 3.

they are small or easily fusible. This can be done by inserting a variable resistance in the circuit of the primary, or by inserting into the same circuit a coil of wire with a movable iron wire core, the positions of which will govern the force of the primary currents. Another good plan is to vary the power of the field magnets of the alternating current machine in any of the various ways known for accomplishing such result.

To effect an electric weld, the pieces are rubbed bright near the ends to be joined, so as to ensure a good electrical contact with the clamps by which the pieces are held, the pieces being firmly bound therein with their ends abutted in the space existing between the clamps, so as to leave a small portion of the bar projecting free of the clamps to the meeting point.

The ends abutted are, of course, kept clean to form good contact, and a little powdered borax is applied as a flux, usually after the pieces have been abutted; or, if the metal be of low melting point, as tin or lead, a little zinc chloride, resin or tallow is applied.

When the pieces are of the same metal and of the same size or section, the junction is made by placing the ends of the pieces abutted midway between the clamps before applying the pressure to force them together and the current to weld them. But when they are of different metals or of different sections, the abutment or meeting point is placed nearer the clamp carrying the most resisting metal; or, the piece of smaller section, or the metal most readily fused, as the case may be, is so placed as to project least, for the purpose of favouring the accumulation of heat in the other piece.

In joining pieces of different diameters the end of the large piece is reduced to the size of the smaller before attempting to effect the weld. It is, of course, best to have the clamps formed to fit the pieces, especially when the pieces are of irregular outline, but for round or square bars, simple V-grooves in the clamps suffice to hold the pieces in place and to give the requisite electrical contact with them. When the pieces are in place and pressed together by the means provided, the current is turned on, and at once the ends of the bars heat where abutted, a slight yielding or approach of the pieces takes place, and, more quickly than the operation could be described in words, the work is done. Sometimes the joint is pressed or hammered to still further perfect and consolidate the weld. This can often be done while the pieces are in place in the clamps, and while the heat is maintained by the current.

Whether the electric current has any peculiar action in assisting the welding I do not know, but I am inclined to think that, in some cases, it has some such influence, although much the larger effect is the simple

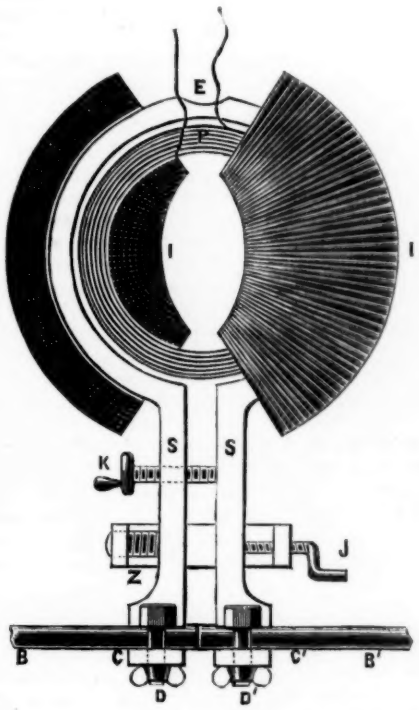

FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF COIL IN FIG. 3.

result of heat and pressure. One circumstance, however, arising out of the electrical properties of the metals subjected to the action, may be noticed. This is the tendency exhibited toward a uniform heating of the section of the abutted bars, as a consequence of the fact that cold metal is a better conductor than hot metal, and that, therefore, any cooler line of particles in the section at once becomes the path for increased current and is brought up in temperature to equality with the other portions.

I would call attention to the fact that in the economical application of electric welding, cheap water power can be utilised to furnish the energy necessary, and that by conveying the currents over lines it can be utilised at distances from the site of the water power.

It only remains for me, before closing the present paper, to mention the fact that I am preparing to have specimens of metals which have been welded electrically, subjected to tests of tensile strength, &c., to determine what proportionate strength exists at the welded portion of the bar. That the strength is great, the rough tests of specimens leave no doubt, but it is

desirable to have the exact data. In illustration of this point, I would mention the case of a lag screw, which was shortened by cutting out a section and welding the square head and screw portion together again. The weld was far less perfect than usual, as was easily seen, little or no expansion at the weld having taken place. Nevertheless, in turning the resulting screw into a block of hard wood by a wrench applied to the head, it twisted off an inch or two below the weld, and the fracture shows that the metal was sound and strong at the point of breaking, while the weld was, of course, unaffected.

Among the curious things noticed in the use of the apparatus is the loud sound or snap due to the extra current in the secondary when the pieces in the clamps are not permitted to move together as the metal softens, and a rupture of the secondary circuit occurs between the pieces. This rupture, although occuring in a circuit whose length is a very few feet, is attended with a very loud snap, a bright flash and forcible ejection of hot particles of metal, as if a fulminate cap had been fired between the pieces. I have seen this action throw white hot pieces of fused steel as large as peas a distance of six feet, and this fact suggests the advisability of keeping the eyesight out of line with the discharge.

As curious instances of work accomplished I may mention broken twist drills mended in the twisted portion, one specimen showing two joints made in the twisted portion of a twist drill Another curiosity is a bar composed of steel, brass and copper pieces joined end to end. Penknives which have lost their blades by breakage close to the handle have had new pieces of steel, which have been subsequently ground into blades, welded to the stumps of the old blades, such stumps projecting scarcely an eighth of an inch from the handle, and the welding has been done without removing the stump from the tortoise shell or other handle. Several other penknives have been thus resuscitated, and I am pleased to say that in the only instance thus far in which a subsequent breakage of the blade has occurred, it gave way at a distance from the weld.

Iron wire rings have been made of many short pieces of wire, and afterwards violently twisted and bent so as to produce short "kinks" without parting, although the short bends included the welded portions. Long pieces of copper wire have been made of a number of short pieces, and afterwards twisted in like manner without yielding at the joints.

The accuracy of the work done depends upon the true alignment of the clamps for holding the pieces, or upon their true adjustment as to relative position, when the pieces are of irregular form. For irregular work, the clamps should be capable of being shifted into various relative positions, a condition not difficult to secure.

The Snowstorm and the Telephone Wires.—Mr. Brand, the chairman of the United Telephone Company, has been interviewed respecting the damage to the wires of his company caused by the recent snowstorm. "The cost of our repairs," he said, "will certainly not exceed £5,000. None of the cables gave way, and we had as many as 12,000 messages on the first day after the storm, and as we have spared no effort or expense to re-establish communications, that number was very speedily added to. We first of all directed our attention to making good the principal pole routes, as we term them, and after we had attended to the great highways, the mending of individual wires was proceeded with. We shall very shortly have our whole communications restored; and, considering the unfavourable weather and the shortness of the working day, that is not a bad result. Our trunk lines stood the strain admirably, although here and there poles bent or broke; but the weakness was as often as not in the roof, rather than in the lines and their supports."

NOTES.

Electric Lighting in Bradford.—A striking illustration of the manner in which electric lighting would be taken advantage of by the public generally were it not hampered by the restrictions of the Electric Lighting Act is afforded by a recent extension of its use in Bradford. In the centre of the shop-keeping part of that town stands a triangular block of buildings, the different sides of which face Kirkgate, Queensgate, and Ivegate, and form together a total frontage of several hundred yards. The works of Messrs. Schmidt, Douglas & Co., electrical engineers, are situated in the centre of the block, and that firm is, therefore, in a position to light up the triangle without crossing any street, and, consequently, without requiring any license from the Corporation or the Board of Trade. A special engine and two Schuckert dynamos are already in full use, the leads to the different shops being carried over private property. Incandescent lamps are used to light the inside of the buildings, and arc lamps are hung in an effective manner outside over the windows of the large retail shops, and in the doors of hotels, coffee-taverns, &c. More plant will have to be laid down to meet further demands, and the contractors hope before long to drive the gas company out of the block altogether. It is certain that this successful introduction of public lighting has given an impetus to the new industry in other parts of the town.

At the monthly meeting of the Bradford Town Council held last week a question was asked as to what the Corporation proposed to do concerning electric lighting, in view of the growing demand for it throughout the town. The Chairman of the Gas Committee said that an enterprising firm of electricians in the town, Messrs. Schmidt and Douglas, had lighted up with arc lamps a considerable block of property in the centre of Bradford. A great number of applications were made for the use of electricity in other parts of the town, and it would be for the committee to consider whether they would play the part of the dog in the manger, or whether, in case they did not undertake to supply electric light themselves, they would allow others to do so. His own opinion was that the Corporation ought not to take the former course, and, in order that the matter might be considered, he called a special meeting of the Gas Committee the other day, when the matter was very fully gone into. The subject was adjourned, however, until several questions which had to be asked of the Board of Trade with regard to the restrictions under which the Corporation was now placed could be answered. The answer had now been received, and at the next meeting of the committee the question would be considered, and Messrs. Schmidt and Douglas would either be allowed to extend their electric lighting in certain districts and under certain restrictions, on payment of a royalty to the Corporation, or the latter would undertake to put down plant of their own to supply electric light to those who wanted it.

An Unfortunate Collapse.—Last Friday evening a series of experiments in electric lighting were arranged to have been carried out at Plymouth, under the auspices of a committee of tradesmen anxious to advance with the times and to take advantage of the best illuminant in the market. Messrs. Laing, Wharton and Down had laid on the necessary apparatus to a number of shops. An engine was hired to supply the motive power, and when the proceedings were started "all went merry as a marriage bell." The light shone out brightly and without a flicker for some little time, and the consternation may, therefore, well be imagined when, all of a sudden, it died out. An examination showed that there was a leak in the boiler, and that this alone occasioned the mishap. Another try will be made.

The Maxim-Weston Electric Company.—What is said to be one of the finest installations in London has

just been completed by the Maxim-Weston Company at Messrs. Chas. Gask & Co's. premises in Oxford Street. Arc and incandescent lamps to the extent of 50,000 C.P. are employed, the incandescent lamps being of the new Weston wavy filament type. The arc lamps are the design of the works' manager of the company; they have brass bases and look very handsome. The Maxim-Weston Company has also completed five large installations in the North, one consisting of nearly 40 arc lamps of 2,000 C.P., another of 30 arc lamps, a third of 500 incandescent lamps, and two others of 250 incandescent lamps each.

Tenders Wanted.—Tenders are invited for the lighting of 254 and 256, Coventry Road, Birmingham, by electricity. Price complete, with engine, to be stated to Messrs. Foster Brothers. Tenders have also been invited for the best and most economical mode of lighting a new workshop, now approaching completion, for the Gloucester Waggon Company. Proposals may be for lighting by gas, electricity, or otherwise, and may include also methods applicable to raising steam in boilers, and to heating iron rivets and scrap iron for forges.

Arc Lighting.—The Anglo-American Brush Electric Light Corporation may be congratulated upon the excellent working of its arc lamp installation in the last Exhibition at South Kensington. The Pilsen-Joel Company has also every reason to be satisfied with the report of the Electric Light Commissioners, but Messrs. Crompton & Co. appear to have been somewhat unlucky owing to "causes and mishaps unforeseen."

Electric Light Installation in Oxford Street.—The Silvertown Telegraph Works Company has just completed the electric lighting of Messrs. Collinson and Lock's show rooms at 76 to 80, Oxford Street. The generating plant consists of a "Silvertown" self-regulating dynamo machine, type "D," having a maximum output of 105 volts and 200 ampères at 550 revs., driven by a compound semi-fixed engine by Ruston, Proctor & Co., which is also used for driving wood-working machinery, power being transmitted to the dynamo by an India rubber belt direct from a clutch-pulley on the engine shaft. The lamps are Edison-Swan 100-volt lamps, the number in use being 237 of 16-C.P and 28 of 8-C.P., but it is proposed to increase this number by a cluster of six 100-C.P. as an outside light. The installation has been carefully carried out in accordance with fire office rules, all switches and fuses being either on slate bases or mounted on asbestos, the conductors being of ample capacity and heavily insulated with India-rubber, this last being a point to which the contractors pay very particular attention, as they consider it of the first importance. We are informed that this installation has given great satisfaction, and as the show rooms are fitted up as rooms in a private house, we hope it may lead to a further extension of the electric light in that direction.

Electric Lighting at the Manchester Jubilee Exhibition.—The arrangements for the entire lighting of the buildings and grounds of the Manchester Jubilee Exhibition are now complete. The various courts have been divided into six distinct sections, and the dynamos will be divided between different engines. Thus, to light section one, which includes more than half of the entire buildings on the north-east portion of Talbot Road, and which contains about 105,800 square feet of floor space, 125 arc lamps will be required, and the current for these will be supplied from three separate dynamo machines, and carried through the lamps by three distinct circuits. These three dynamo machines are again divided between three different engines, driving a separate range of counter-shafting. The main buildings, with the gallery of approach and the Botanical Gardens, will be illuminated by means of 353 arc lamps; while the machinery in motion section, with its annexe and grounds, will require no less than 193 lamps, making a total of 546 arc lamps of 2,000 candle-power each, and requiring engines capable of exerting, if at any time necessary, a total of 1,000 indicated horse-power. This large supply of arc lamps will be carried out by the Anglo-American Brush Corporation. The Fine Art Galleries will be illuminated by 1,650 16-candle-power Edison-Swan glow lamps, arranged on the roof principals, and fitted with porcelain reflectors. Each separate room will be supplied from at least three distinct circuits. Messrs. Mather and Platt, of Salford, have generously placed the entire generating plant for this section at the service of the executive committee. It comprises two vertical engines and four dynamos of the well-known "Edison-Hopkinson" type, and two dynamos of the "Manchester" type. Messrs. Galloway and Sons have been entrusted with the working arrangements connected with the fairy fountains. The entire system of water pipes, electric connections for the projector lamps fitted underneath the surface of the water, and the signals for the changing of the various coloured effects, will be controlled from a manipulating tower. It is stated that Messrs. Galloway have made several important additions and improvements in this style of ornamental lighting, and that the fairy fountains at the forthcoming exhibition will be on a more complete scale than at the Inventions and Colonial and Indian Exhibitions. The quaint buildings of "Old Manchester and Salford" will be lighted by 600 20-candle-power Edison-Swan glow lamps placed throughout the shops, while two large arc lamps, suspended on a mast 100 feet high, will throw a diffused moonlight effect on the streets below. The Palm House dining room will be one of the finest pieces of decorative lighting in the exhibition. Throughout the foliage, peeping from underneath the ferns and hanging from all points, will be 750 glow lamps. For the lighting of the Fine Art Galleries, the Palm House dining room, and "Old Manchester and Salford," the tender of the Manchester District Edison Company has been accepted. The whole of the arrangements have been made by Mr. William A. Bryson, electrician to the International Exhibition held in Edinburgh last year, who has been appointed electrician to this exhibition, and the installation will be under his control.

Electric Light in Shropshire.—At a fancy ball given by Mr. T. S. Eyton, of Walford Hall, Shrewsbury, the ball, and supper, and retiring rooms, were lighted by means of the electric light. Incandescent lamps were used and fed by Elwell-Parker accumulators of the new portable form. These were charged at Shrewsbury and forwarded by rail to Walford. The beauty of the light was further enhanced by an artistic arrangement of fancy paper shades placed over the lamps. At the Shropshire Hunt Ball, given on Thursday last week at the Music Hall, Shrewsbury, the room was illuminated by the same means. In each case special care had to be taken in running leads, &c., in order to prevent any injury to the various decorations. On former occasions the temperatures were respectively 85° Fah. and 79°, whilst on these occasions the thermometer indicated 63° and 61° respectively. The whole of the work in connection with the above installations was carried out by Messrs. Alltree & Lea, of Shrewsbury. From the same firm we hear of private house lighting being carried out by means of portable secondary cells, charged at their Chester Street Works, and thence forwarded ready for use to their customers. The lamps used in this form of lighting are of 12 volts and 24 volts, according to size of installation and circumstances. In all cases the results have been most satisfactory, and by this means many persons are able to have the electric light in a cheap convenient form.

Quick Telegraphing. — On December 19th, the Canadian Pacific Railway, working in connection with the Commercial Cable, had a test of speed between New Westminster, B.C., and London. Messages were exchanged, it is said, in one minute.

A Bad Look-out for the U. T. Company.—The *Financial News* states that an enterprising business firm in the City have sent out notices to their customers that, owing to the interruption of communication over the telephone wires, they have ceased to be subscribers to the telephone system, and they accordingly invite their customers to communicate with them hereafter by telegraph at the firm's expense. This example, says our contemporary, is likely to be generally followed unless the United Telephone Company shows more enterprise and more intelligence than it has recently displayed.

Proposed Telephonic Extension. — The Western Counties and South Wales Telephone Company, which has already displayed so much vigour in the discovery of "fresh fields and pastures new," contemplates offering to start exchanges at Winchester, Ringwood, Romsey, and other towns, besides placing Bournemouth, Southampton, and Portsmouth in direct intercommunication.

Margate and Ramsgate Connected by Telephone.—The New Telephone Company's instruments have just been fixed at Margate and Ramsgate, and these favourite watering places are now telephonically connected for the first time. There are two lines (each 6½ miles in length), one connecting Messrs. Wastall & Co.'s offices in Margate with the Ramsgate branch, and the other connecting the Ramsgate and Margate offices of Messrs. Sankey & Sankey. The lines have been erected by Mr. W. Covington, of Canterbury, and the instruments have been fixed by one of the company's inspectors, and the most unqualified satisfaction was expressed with the working by all parties concerned.

The Gulf Stream.—In our next issue we hope to publish some notes on the Gulf Stream which, although not strictly connected with electrical matters, are eminently readable, and of some interest to those engaged in cable laying operations.

The Union Storage Battery.—We have just been informed that the company holding the patents for the above-named battery will, within the next day or two, ask for public subscription to form capital to the amount of £500,000.

An Incident of Gas Lighting.—On Monday night of last week a link of a chain holding one of the large gasometers of the Todmorden Gas Company broke, and the gas escaped. As a result the mills and workshops had to be closed at five o'clock. The shops were also in darkness.

The Society of Telegraph-Engineers and Electricians.—The next meeting will be at the Institution of Civil Engineers, 25, Great George Street, S.W., on Thursday, January 27th, at 8 p.m., "Telephonic Investigations," by Prof. Silvanus Thompson, B.A., D.Sc., member.

Shot Recording by Electricity.—A new underground range, beneath the premises of the Imperial Club, Cursitor Street, Chancery Lane, was opened last week. The value of each shot was instantaneously recorded by electricity, and the arrangement worked most satisfactorily. The system was invented by Lieut. Dudley Wilson.

Overhead Wires in the City.—At the recent meeting of City Commissioners of Sewers, Mr. Altman called attention to the serious breakdown of telegraph and telephone wires and poles in the City, and moved, "That it be referred to the Streets Committee to consider and report what arrangements, if any, could be made to prevent telegraph and telephone companies having their wires and posts fixed to the roofs of houses and buildings in the City, and if some other mode could not be devised." Mr. Bridgman seconded the motion, which was carried.

Personal.—We regret that Mr. Reckenzaun, whose contributions to our columns are always welcomed by our readers, has not yet sufficiently recovered from his illness, to which we referred last week, to undertake the return journey from Austria. As will be seen, however, he has yet enough stored energy to continue his articles on secondary batteries.

Against Animal Power.—The day of horse cars on our crowded streets, says the *Boston Herald*, is drawing to a close. This is the age of machinery, and passengers can be moved by much more economical, more efficient and cleaner agencies than animal power. In a short time they will be as much behind the age as stage coaches and town criers.

Good Dynamos.—The Edison-Hopkinson dynamos are well spoken of in the report of the Electric Lighting Committee of the Colonial and Indian Exhibition, as are also those of Messrs. Siemens Bros. and Elwell-Parker. The garden illumination, for which the two last-named types of machine were used, reflects great credit upon the firm of Messrs. Galloway and Sons, whose fine engines and boilers were used to supply the motive power.

Secondary Batteries.—Information relative to the performance of the E.P.S secondary batteries, may be found in the detailed technical reports of the South Kensington Exhibition lighting on p. 47 of this issue.

Galvanometers. — Quite recently Mr. R. H. M. Bosanquet drew attention in the pages of the *Philosophical Magazine* to some eccentricities of a galvanometer used by him. This has brought Mr. Thomas Gray, B.Sc., to the fore with a paper on "Silk *v.* wire suspensions in galvanometers, and on the rigidity of silk fibres." Pressure on our space compels us to withhold this very interesting article.

The Davey-Paxman Engines.—The performance of the engines supplied by Messrs. Davey-Paxman & Co. to the Colonial and Indian Exhibition appears to have been of an exceedingly satisfactory nature, judging from the report of the Electric Lighting Committee, a portion of which may be found in this issue of the REVIEW.

The Indicator Diagram.—A special course of six evening lectures on "The Indicator Diagram," will be delivered by Professor John Perry, M.E., D.Sc., F.R.S., on every other Thursday, at 7 o'clock. These lectures given at the Finsbury Technical College commenced last night, and they are of paramount importance to mechanical and electrical engineers. The programme of the college, and full particulars of the work of the institute, may be obtained at the college, Leonard Street, City Road, E.C.; or at the office of the institute, Gresham Colllege, E.C.

Electrical Engineering at King's College.—Prof. W. Grylls Adams, F.R.S., will deliver a course of lectures on magnetism, dynamic-electricity, electromagnetism and their applications to dynamo machinery, electric lighting, transmission of power, &c., during the present session. A course of practical work in electrical testing and measurement with especial reference to electrical engineering will also be carried on under his direction in the Wheatstone laboratory. The lectures will be given once a week, on Mondays at 2 p.m., and the laboratory will be open daily from 1 to 4 except on Saturdays.

A New Primary Battery.—Mr. Sydney F. Walker writes to us thus:—"Kindly allow me to correct a clerical error in the description of the above, which I sent you last week. In the last paragraph it should be stated that the action of the battery is maintained at the expense of the zinc and sulphur, not of the sulphur alone. In reply to your criticism *re* internal resistance, this is evidently due to the larger proportion of carbon used."

The Electrical Industry in Bristol.—The *Bristol Times and Mirror* publishes an interesting description of the extensive works of Messrs. King, Mendham and Co., together with a sketch of the history of that firm, which seems to have developed from a small optical business carried on by Mr. King 35 years ago.

Fatal Accident at the Grosvenor Gallery.—The promotors of the Grosvenor Gallery lighting scheme seem to be dogged by misfortune. Last week one of the workmen was killed whilst engaged in removing some machinery from the electric light engine room.

The Dangers of Gas.—A fire, caused by an escape of gas, broke out early one morning last week at a private residence in Camberwell Grove, Camberwell. The fire rapidly spread, doing much damage, the adjacent house also suffering.

Electric Cars in New York.—The Julien electric car has had another trial on the Eighth Avenue Railroad in New York, which is said to have been entirely successful. A lever on the platform regulates the speed, or cuts off the power entirely as may be desired.

The Snowstorm and the Wires.—The Post Office has issued a notice cancelling all its recent intimations about delay in the telegraphic service, so it may be concluded that the damage caused by the recent snowstorm has been repaired.

Electric Welding.—We have already described the process of electric welding which has been brought to such a degree of perfection by Prof. Elihu Thomson; but the paper which we publish to-day from the *Electrical World* is so complete, that it seemed to us worth bringing before the notice of our readers in its entirety as the best article on the subject yet produced.

The Kilowatt.—Our readers will find the report of the Electric Lighting Committee of the Indian and Colonial Exhibition to contain much interesting information, but the constant recurrence of the "Kilowatt" rather tries one's patience. The term which is more generally used to express the same thing has the merit of being shorter and less exasperating.

The Life of Glow Lamps.—It appears that the Edison-Swan new lamps are not nearly so long-lived as those of earlier years. The old 96 volt Edison lamp shows the longest life.

Elieson's Electric Tramway System.—Yesterday we took a trip on one of Elieson's electric locomotives, and next week we shall give our further impressions of the system. Our readers are aware that at the time we gave a description of Elieson's method of gearing we did not sing its praises very loudly, as we were under the belief that the inventor had adopted a very clumsy method of attaining a certain end. The gearing remains the same, but as its action is all that can be desired, and as it can be shown that this system of tramcar propulsion is much cheaper than that of horse traction, we shall not be disposed to criticise the invention adversely. We may briefly state that the trip, in which some 60 gentlemen took part, was a thorough success.

The Grosvenor Gallery Lighting Station.—A correspondent writes us respecting the arrangements in connection with the central station at the Grosvenor Gallery, as follows:—Having read the leading article in your paper, in reference to the accident on the Grosvenor Gallery circuit, I side with what you say as to the great neglect of not giving proper instructions as to the cutting off the supply of current in the case of emergency, and also in connecting up the apparatus and wire.

Wreck of a Dynamo.—On Wednesday great alarm was caused in the neighbourhood of the new museum buildings in Kildare Street, Dublin, by the breaking up of the large machine used for producing the electric light in the buildings.

Sale of Electric Lighting Plant.—An important sale of boilers, engines, electrical machinery and effects, is to be conducted by Messrs. Wheatley Kirk, Price and Goulty at the Colonial and Indian Exhibition buildings on Wednesday next, the 26th; particulars will be found in our advertisement columns.

Lecture on the Telephone.—At the Memorial Hall, London Street, Bethnal Green, last week, the first of a series of "penny science lectures" was delivered before a large audience of working men, the lecturer being Mr. W. Lant Carpenter, B.A., of the School of Electrical Engineering, and the subject of the lecture "The Telephone; or, Talking by Electricity." Mr. G. H. Barber Beaumont briefly introduced Mr. Carpenter, who proceeded to deliver a most interesting discourse, which he illustrated by experiments and numerous photographs, shown by the oxy-hydrogen lantern. As an instance of the perfectness of the telephone of to-day, he said that when in New Zealand a short time ago he conversed by its aid with a man 240 miles off, and in New York he had talked with a man who was 600 miles away, and heard his voice quite distinctly. Mr. Carpenter explained the mechanism of the telephonic apparatus, and showed by experiments how it was that the sound was conveyed through the wires, and thence to the ear of the person at the end. At the close of the lecture, Mr. D. Munro moved a vote of thanks to Mr. Carpenter, which was carried by acclamation.

Obituary.—Mr. John Arthur Phillips, whose death was announced last week, was born in November, 1822, at Polgooth, near St. Austell. Several members of his family had been long connected with that important tin mine, and from them he inherited a love of mining and metallurgy, which he displayed to the end of his life. On May 4th, 1839, there appeared in the *Athenæum* the first account of the now familiar process of electro-metallurgy. This new process attracted much attention, and young Phillips was led to make experiments. On October 4th, 1842, he visited the annual exhibition of the Royal Cornwall Polytechnic Society at Falmouth, and exhibited a specimen of "electro-lace," as he called it. This was a piece of very fine lace delicately and completely covered with pure metallic copper, which he had deposited upon the threads (previously coated with a good conductor of electricity) by the agency of an electric current. For this specimen of the new metallurgy—the first of its kind that had been publicly exhibited—the Polytechnic Society awarded to Mr. Phillips their first prize. This success led him onward, and we find him immediately after taking advantage of his connection with the mines around St. Austell by carrying on an inquiry into the electrical phenomena of mineral lodes, instituted by Mr. Robert Were Fox, with whom he made acquaintance during his visit to Falmouth. Feeling the deficiencies of his scientific education, he entered the Ecole des Mines at Paris in 1844, and after passing through the regular course of instruction there, obtained the situation of engineer to one of the large French collieries. Later he was connected with enquires instituted by the British Admiralty into the qualities of coal. In 1872 he was elected a Fellow of the Geological Society, and was admitted a Fellow of the Royal Society on June 2nd, 1881. Mr. Phillips was the author of works on metallurgy, and contributed numerous memoirs on metallurgy and mining to various scientific journals.

Croydon and its Gas Works.—A public meeting was held at Croydon last week to consider the proposed purchase of the Croydon gas works by the Corporation, the Mayor presiding. The resolution in favour of the purchase was negatived by 600 votes to 50. "They could see the electric light brightening the world around them and darkening gas," said Mr. Stent. "Talk about the impossibility of adapting the electric light to public uses, was simply the remains of a strong, ardent faith in coal gas which was dying out."

Southampton Telephone Exchange.—The number of members belonging to this exchange, which was started some six months since, is now nearly fifty. Some statistics have been published showing that during the period of the exchange's existence there have been 17,300 calls, or an average of 185 messages per day. At the local centre the switch room has undergone considerable remodelling. The board has been altered so as to provide for 100 subscribers. Two operators are employed. Considerable care has been taken to render the wires and the poles supporting them as strong as possible, and with this view no standard is used less than 48 feet in length.

The Causes of Fire.—In the 13th annual report of the Board of Fire Commissioners of Boston for the year ending April 30, 1886, there is a table giving "the different causes of fires;" and it is a noticeable fact that while "27 were due to gas, and 74 to kerosene lamps and stoves," only 4 were attributed "to electric wires."

Electric Lighting of Balloons.—In a lecture on "War and Ballooning," delivered recently at the London Institution, Mr. Eric S. Bruce spoke in highly appreciative terms of the excellence of the Schanschieff battery for lighting his balloons. He said he had searched for some time to find a primary battery that was anything near the mark for electric lighting purposes; the Schanschieff was the best he had had in his hands, and he was applying it to several of his patent arrangements. With most single-fluid batteries polarisation occurred, but Mr. Schanschieff had overcome this, and in doing so had done a great deal towards the development of electrical appliances.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Pilsen-Joel and General Electric Light Company, Limited.—The annual return of this company, made up to the 6th inst., was filed on the 17th inst. The nominal capital is £56,225 divided into 28,000 shares of £2 each, and 100 shares of £2 5s. each; 24,483 of the former, and the whole of the latter, have been taken up. The 100 shares of £2 5s. each are fully paid, and £1 5s. per share has been called up on 24,483 shares. The calls received amount to £59,483 15s., but this amount has been reduced by order of the Court, and the paid up capital at present stands at £30,828 15s. The calls unpaid amount to £3,516 5s. Upon 3,517 shares forfeited, the sum of £2,656 has been paid.

W. T. Henley's Electric Light and Power Company, Limited.—The annual return of this company, made up to the 7th inst., was filed on the 17th inst. The nominal capital is £100,000 in £1 shares; 6,918 shares have been taken up, and a call of £1 has been made thereon. The calls paid amount to £6,911, and unpaid to £7. The sum of £41 10s. 11d. has been paid on 101 shares forfeited.

Spanish National Submarine Telegraph Company, Limited.—The annual return of this company, made up to the 4th inst., was filed on the 17th inst. The nominal capital is £500,000 divided into 49,900 shares of £10 each, and 1,000 shares of £1 each; 23,719 of the £10 shares have been taken up, and the full amount has been called thereupon. The calls paid amount to £30, and the sum of £237,160 is deemed to have been received. The total amount of the shares for which share warrants are outstanding is £23,040.

Lay Torpedo Company, Limited.—An agreement of 18th ult., filed on the 20th ult., provides for the purchase by the company of interests of certain persons who have been engaged with Mr. John Louis Lay in carrying out experiments for discovering and perfecting improvements in the construction of a class of torpedo called the Lay Torpedo, the result of such experiments being the construction of a specimen torpedo which possesses mechanism which is said to contain a secret process of a novel and valuable nature. The purchase consideration is the allotment of shares as follows:—To Mrs. Gertrude Wallis 8,551 ordinary fully paid shares, 3,444 fully paid shares, the scrip of which will be retained by the company, and of which no transfer may be made until the 1st January, 1889; to Mr. Andrew Dexter 2,026 fully paid ordinary shares and 854 fully paid shares, the scrip of which will be retained by the company; to Mr. R. H. Heenan, 3,423 ordinary fully paid shares and 1,377 fully paid shares, the scrip of which will be retained by the company.

Telpherage Company, Limited.—The registered office of this company is now situate at Winchester House, 50, Old Broad Street.

CITY NOTES.

The Direct United States Cable Company, Limited.

THE report of the directors for the six months ended 31st December, 1886, states that the revenue for the half-year, after deducting out-payments, amounted to £19,603 6s. 11d., against £38,115 3s. 5d. (after similar deductions) for the corresponding period of 1885, being a difference of £18,511 16s. 6d., against the half-year under review, owing to the reduced tariff referred to in the last report, the competition and low rates still continuing. The working and other expenses for the same period, including income tax, &c., but exclusive of cost of repairs of cables, amounted to £16,354 7s. 6d., leaving a balance of £3,248 19s. 5d., as the net profit of the half-year, making with £3,050 19s. 3d. brought forward from the previous half-year, a total balance of £6,299 18s. 8d. For the corresponding half-year of 1885 the working expenses and other payments amounted to £16,631 13s. 0d. An interim dividend of 2s. per share for the quarter ending September 30th, 1886, was paid on the 30th October, 1886. It is now proposed to pay for the quarter ending 31st December, 1886, a further interim dividend at the same amount per share; for this purpose recourse will be had to the reserve fund.

A break occurred in the short section of cable on the 3rd August last, and was repaired on the 7th of September.

Eastern Telegraph Company, Limited.

THE report of the directors for the half-year ended 30th September, 1886, states that the revenue for the period amounted to £292,229 17s. 8d., from which are deducted £81,025 9s. 10d. for the ordinary expenses, and £53,965 5s. 5d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £4,677 3s. 0d. for income-tax, there remains a balance of £152,561 19s. 5d., to which is added £4,079 2s. 8d. brought from the preceding half-year, making a total available balance of £156,641 2s. 1d.

From this balance there have been paid—

Interest on debentures and debenture Stock	£28,252	8	2
Dividend on preference shares	20,296	15	9
Two interim dividends of 1½ per cent. each on ordinary shares	95,000	0	0
	£143,549	3	11

Leaving a balance of £13,091 18s. 2d. which is carried forward to the next account.

The revenue includes £15,600 dividend for the half year upon the company's shares in the Eastern and South African Telegraph Company, and also £3,570 10s. 0d. net receipts for the half-year on the shares of the Black Sea Telegraph Company belonging to this company. The cables of these companies are in good working order.

The present accounts include the receipts for three months' working under the reduced tariffs fixed at the International Telegraph Conference in Berlin last year.

The several sections of this company's cables and the lanp lines in connection therewith are in good working order. The outlay in connection with repairs and renewals has been exceptionally large for the past half-year, mainly due to renewals of the Direct Lisbon Line, upon which 191 knots of new cable have been used; three-fourths of this cable have now been renewed out of revenue.

The establishment of telegraphic communication with the British possessions on the West Coast of Africa by the African Direct Compnny was completed in September last. It is as yet too early to ascertain the probable traffic over the lines.

The Western and Brazilian Telegraph Company, Limited.—The directors have decided to change the company's financial year from October to September, to January and Decem-

ber, in accordance with the more general rule, and in correspondence with the Brazilian Submarine Telegraph Company, Limited, with which this company has working agreements. The next account, therefore, will embrace a period of 15 months, viz., from October 1st, 1885, to the 31st December, 1886.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending January 14th were £3,719 after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th January are £2,935, as compared with £2,639 in the corresponding period of 1886.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts of this company for the week ending January 14th amounted to £4,701.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this Society was held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday evening, January 13th, Professor D. E. HUGHES, F.R.S., President, in the chair.

The minutes of the Annual General Meeting were confirmed, and the names of new members and transfers announced.

The PRESIDENT said it was his painful duty to announce the death of Colonel Sir Francis Bolton, who was one of the most esteemed members of the Society. The loss was very greatly deplored, and the council of the Society felt that the first opportunity should not be lost of moving a resolution of sympathy and condolence to Lady Bolton. The resolution of the council was "That the president, council and members of the Society of Telegraph-Engineers and Electricians desire to record the deep regret occasioned to them by the death of Colonel Sir Francis Bolton, Vice-President and Honorary Secretary, who was one of the founders of the Society, and to whose energy and liberality much of its early success was due; and they further desire to express their sincere sympathy with Lady Bolton in her bereavement."

Major General C. E. WEBBER said that all present must regret that at the opening meeting of the year 1887 it was their painful necessity to deplore the loss of one who had been so prominently among them for so many years. He hoped that the meeting would excuse his mentioning a few facts in connection with the career of Colonel Sir Francis Bolton, especially in connection with the Society. He had known him as a friend for twenty years, and at the time of their first acquaintance Colonel Bolton had already distinguished himself in the army, and was serving as assistant quartermaster-general at Chatham, instructing Royal Engineer officers in signalling and military telegraphy, having been selected for the work by that good old soldier Sir John Burgoyne. Colonel Bolton soon after brought out a code book, which was for many years the means of bringing the army and navy together for considering the question of communication by visual signalling. About May, 1870, the first idea of starting a Society of Telegraph-Engineers occurred to the speaker after attending a meeting of the Association of Gas Engineers and Managers, and, aided by the bright foresight of Colonel Bolton and the assistance of the late Mr. Sabine, the birth of the present Society shortly afterwards took place. He gave Colonel Bolton the sole credit for the existence of the Society, as it was owing to his ideas as to the future position of electricity that the scheme was realised. During late years other occupations had attracted Sir Francis Bolton, but he never allowed anything to interfere with the interest he took in the Society, which he always assisted in every possible way. Colonel Sir Francis Bolton's life had been one of unceasing toil, and few men were capable of getting through so much work as he in twenty-four hours; his energies had principally been devoted to the advancement of science, and he literally died in harness, having seen many letters on the morning before his death. The memory of such a man, especially as founder of the Society, would remain for many years, and he (General Webber) cordially agreed with the proposed letter of condolence and sympathy to Lady Bolton for the loss of their departed brother.

The motion was unanimously carried.

The PRESIDENT presented the premiums awarded to the authors of papers which were found to possess sufficient deserving merit. The premium of the Society, value £10, was, in the shape of a microscope, handed to Mr. A. Bernstein for his paper on "Electric Lighting by means of low resistance glow lamps." The Paris Exhibition premium of £5 was, in the shape of a clock, presented to Captain H. R. Sankey, R.E., for his paper, "On a problem relating to the economical electrolytic deposition of copper." The Fahie premium of £5 was given to Mr. H. Kingsford for his paper, "On a method of localising a fault in a cable by testing from one end only," the present taking the form of two volumes of Clerk-Maxwell on Electricity.

Professor HUGHES then thanked the members for their assistance during his term of office, and vacated the chair in favour of the President elect, Sir Charles T. Bright.

Professor FORBES proposed a hearty vote of thanks to Professor Hughes for the able way in which he had conducted the duties of the chair during the past year. He had always felt that the name of Professor Hughes stood very high in the opinion of the world, not only in connection with his inventions, such as the printing telegraph instrument, the microphone, and induction balance, but on account of his being a pure lover of science, who carried on investigations with the object of finding out new facts from nature. Moreover, apart from those qualifications, he had assiduously devoted himself to the performance of the duties of President, and was in every sense deserving of the thanks of the Society.

Mr. W. H. PREECE, seconded the motion, which was heartily carried.

Professor HUGHES, in acknowledging the vote, paid high compliments to the Members of Council, and the Secretary (Mr. F. H. Webb), for their valuable assistance in rendering agreeable those duties which he had feared would otherwise have been most arduous.

Sir CHARLES T. BRIGHT then read the following

INAUGURAL ADDRESS.

In addressing you at the first meeting of our new session, I wish in the first place to express my most cordial thanks for the honour conferred upon me in being elected to the office of President during the present year, the more so because it is a period specially interesting to us, as in it occurs the Jubilee of the Accession of our beloved Sovereign, and also of the first practical realisation of the electric telegraph.

I am glad to be able to state that our Society continues to flourish; and to maintain its justly acquired reputation for the value and utility of the papers read, and of the discussions upon them; which are often of more importance than even the papers themselves, as bringing forward views and information on different sides of the questions raised; and, while I refer to this, I wish to say that I should like to hear more, if possible, during the discussions in the course of this session, from those who have not been so long in the Society as some of us, and the only way to obtain this result is that those who join in the early part of any discussion should make their remarks as concise and as much to the point as possible, so that our juniors may have time left to speak.

The total number of our members of all classes is now 1,343. At the first meeting, in February, 1872, it was only 110. At that meeting the President, referring to the *raison d'être* of the Society, adverted to the impossibility of one great scientific body like the Royal Society succeeding in cultivating all the different departments of science in detail; and that therefore other societies, like the Astronomical, the Geological, the Chemical, or our own, were essential for their own especial fields of scientific knowledge and practice.

It is somewhat curious that Dr. Priestly had the same views when, so long as one hundred and twenty years ago, in the preface to his "History of Electricity," he suggested that an Electrical Society should be formed, to be devoted to electrical and kindred investigations. "The business of philosophy," he said, "is so multiplied, that all the books of general philosophical transactions cannot be purchased by many persons or read by any person. It is high time to subdivide the business, that every man may have an opportunity of seeing everything that relates to his own favourite pursuit, and all the various branches of philosophy would find their account in this amicable separation. Let the youngest daughter of the sciences set the example to the rest, and show that she thinks herself considerable enough to make her appearance in the world without the company of her sisters."

This suggestion of Dr. Priestly, made in the year 1767—long before galvanism, electro-magnetism, thermo-electricity, and magneto-electricity were known—bore no fruit, at all events not for many years.

In June, 1837, however, a Society was formed entitled the "London Electrical Society," of which Mr. Gassiot and Mr. Sturgeon were the principal founders, one becoming, subsequently, the Treasurer, the other the first President. The name of the former will be well remembered for his researches in electricity, and for the liberal manner in which he constructed apparatus on a large scale for the purpose. The latter name suggests a long record of experiments, of which the most valuable was his discovery of magnetising bars of soft iron and rapidly changing their polarity, by voltaic currents; in other words, the invention of soft iron electro magnets, which are so largely used in telegraphs, telephones, and almost every kind of electrical appliance.*

Mr. Sturgeon, the President of that Society, in his inaugural address in October, 1837, claimed "that electricity was the most important experimental science ever cultivated by man," and remarked that the preceding forty years had been more productive of electrical discovery than all the antecedent centuries embraced in the history of the science." †

Sturgeon was justified in his conclusion: for those forty years included the labours and discoveries of Volta, Brewster, Arago, Humboldt, Wollaston, Davy, Oersted, Ampère, Schweigger, Ohm, Becquerel, and, above all, of Faraday, who was then in the midst of his ever memorable experiments.

A number of papers, upon almost every branch of electrical science then known, were contributed to the proceedings of the London Electrical Society; part of which were published in its

* *Trans. Soc. of Arts*, vol. xliii., 1825.
† *Annals of Electricity*, vol. ii., p. 64.

Transactions, which will be found in our library, and the remainder in Sturgeon's "Annals of Electricity."

The Society, however, lacked in vitality; there were in its best days only 76 members, and it was finally dissolved in a little less than six years.

The late Mr. C. V. Walker, who was one of its members, having joined in April, 1838, told us, in his presidential address here, all about the decline and fall of that small society. He ultimately became both treasurer and secretary. As treasurer, in the culminating year of decay, he only received £77 with which to pay himself as secretary, for the printing and publishing of the proceedings and all other expenses of the society.

Now our Society of Telegraph-Engineers and Electricians commenced its yearly accounts at the end of 1872 with subscriptions to the amount of £422. In *its* sixth year the treasurer received £1,275, of which £615 was expended in printing and issuing the Society's valuable journal. The income last year amounted to £1,818.

The income of the Society was, during the first years of its existence, almost exclusively derived, as it still is to a very large extent, from the subscriptions of those who are more or less intimately associated with electric telegraphs, for, although every other branch of applied electrical science is now well represented on the list of members, a large contingent of subscriptions still comes from those engaged in the Postal Telegraphs, in the Indian Government Telegraphs, in the large submarine cable companies, and, in fact, from telegraphists spread over the face of the globe; others, again, from the large manufactories connected with the supply of telegraphic instruments, materials, cables, and their accessories. Our Society might well use the motto of the Royal Engineers, "*Ubique*," or let us say, "*Quæ regio in terris nostri non plena laboris.*"

A purely electrical society might perhaps have had more success than its predecessor, at the time when our Society was established, but I doubt it; for, on investigating the practical applications of electricity for the general use of mankind during the last half century, we find that nearly the whole of the work done and capital invested has been connected with electric telegraphs, at all events until 1878, since when a material movement has taken place in the development of electric lighting and telephones.

The earlier part of the present century was one of surpassing interest in the advance of electrical knowledge, and all the requirements for an electric telegraph were at hand: the voltaic battery, the electro magnet, the multiplying coil, the magnetic needle, together with the knowledge that, if suspended, it could be deflected by a galvanic current passing through a fixed coil adjacent to it; all were ready, and it is not to be wondered at that numerous devices for carrying on telegraphic communication by means of electricity were proposed and shown by many philosophers and experimentalists in different parts of the civilised world.

Ampère himself proposed, on the suggestion of the illustrious La Place,* that a telegraph might be made with needles deflected in such a manner as to communicate different letters of the alphabet; and it was subsequently computed, at the trial of an American patent case, that more than sixty claims might be made out for suggestions of various kinds for an electric telegraph prior to its actual realisation.

It is no part of my purpose to attempt to award the proportion of merit due to each or any of the long array of inventors. Hundreds of most promising discoveries have died an early death for lack of industry or perseverance to foster them. The man who begins by inventing, and afterwards struggles through every obstacle and with the greatest difficulty brings it into actual practice, outstrips, to my mind, him who is merely the *projector* of even the most ingenius invention which history records.

A man of genius and perseverance, such as I have pictured, thus expressed himself some years later upon the subject:—

"If the electric telegraph were to be described generally in a few words, how should it be described? Might it not be called an application of a few known principles by means of a few simple contrivances to produce a practical result, which the experiments of scientific men, although their attention had been directed to the subject for a long series of years, had failed to produce? The merits of the invention must therefore consist, to a very great degree at least, in the practical realisation of that which before had been an idea or an experiment."†

The writer of the foregoing was Mr., afterwards Sir William, Cooke, an officer in the Madras Army, who returned from India on furlough in 1831.

The Liverpool and Manchester Railway had been opened for public traffic a few months before, and had proved a great success, the receipts being what was then considered the enormous sum of £250 a day, or a little more than £90,000 per annum. This was derived from fares of 7s. 6d., and three trains running each way daily.

The public were fully appreciative of the boundless advantages of this stupendous power, and the general interest in it was almost without parallel.

Notions of speed and distance were still relative, but their meaning had been changed.

New railways were announced from London to Birmingham, thence to Manchester, and in many other directions. Cooke was a man of great intelligence and scientific tastes, and the effect on the history of telegraphs produced by the interest which this altered state of locomotion awakened in his mind will be seen hereafter.

A few years later, viz., in March, 1836, when at Heidelberg, he saw for the first time, at the lecture-room of the Professor of Natural Philosophy, one of those experiments to which I have referred as being frequently exhibited to illustrate the possibility of telegraphing to a distance by electricity; it was fitted up between the Professor's study and the lecture-room, and consisted of a pair of suspended needles, and fixed coils much after the fashion of Ampère's idea suggested by La Place fifteen years before, which had, however, like many others, been unproductive of any useful result.

Cooke was deeply impressed by this experiment, and with the conviction that electricity might be applied as an instantaneous means of communication for the working of the railway system then extending all over England, as well as for Governmental and general purposes.

So sanguine was he as to the success of his scheme that he at once abandoned his former pursuits and devoted himself exclusively to the practical realisation of an electric telegraph. Within three weeks he made his first telegraph, besides working out numerous supplementary details.

In November, 1836, he showed to Mr. Faraday the apparatus which he had constructed in order to exhibit to the directors of the Liverpool and Manchester line.

No grass had grown under his feet since the idea had flashed on his mind some months before at Heidelberg. He was still absorbed in the first notion which struck him, of associating his electric telegraph with the working of railways for their mutual "safety and economy."*

Early in the next year he became acquainted with Professor Wheatstone, who had been in the habit of showing, in his lecture-room, the feasibility of telegraphing by electricity, using two galvanometers and a permutating key-board by which deflections of the magnetic needles could be exhibited.

There is no occasion here, or in any civilised country, to descant upon the great scientific attainments and achievements of Sir Charles Wheatstone, from his memorable experimental determination of the velocity of electricity, in 1834, to the remarkable recording telegraph apparatus perfected by him in later days with the skilful aid of our ingenious mechanical engineer, Mr. Stroh, a member of our Council.

The result of the two experimentalists becoming known to each other was that they soon after agreed to combine their inventions; a patent in their joint names was applied for, receiving the Great Seal on the 12th June, 1837.

The specification of this, the first patent for electric telegraphs in any country, is very elaborately drawn up, occupying forty-six large printed pages and three large sets of drawings showing the details of their inventions. It comprises a complete reciprocal telegraphic system: indicating instruments of several kinds, sending and receiving keys very much like some of those used even now, methods of supporting and insulating the conducting wires, alarums worked by relays, and means of ascertaining faults in the line-wire by the use of detectors. The wires were to be placed in troughs, being previously covered with cotton and a resinous cement, and with varnish of different colours for the several wires so as to distinguish them in case of repairs being needed.

It will be seen by the foregoing abstract, and still more by any one who will examine this highly interesting specification, that the joint patentees had considered in a most careful manner many of the requisites and contingencies of the work which they were about to undertake. I may add that in after years the validity of the patent was upheld in two cases of infringement. Soon after the patent was granted, permission was given by the directors of the London and Birmingham Railway to lay down the wires between Euston Square and Camden Town Station; and by the latter part of July, 1837, the first practical realisation of the electric telegraph in its application to railway working was ready for trial,

Late in the evening of the 25th of that month, Mr. Cooke and Professor Wheatstone stationed themselves—the one at Camden Town Station, the other at Euston Square. In order to try whether the instruments would work through considerable distances, some miles of wire along which the current had to pass (besides the wires in the open air) were suspended in the large carriage-house near the Euston Square terminus, making the length 19 miles. Several friends of the inventors were present at Camden Town, among others, Mr. Brunel and Mr. Stephenson. Professor Wheatstone first spelt out a message, and on Mr. Cooke quickly and clearly answering from Camden Town, the practical realisation was accomplished. "Never did I feel such a tumultuous sensation before," said the Professor, "as, when all alone in the still room, I heard the needles click, and as I spelled the words I felt all the magnitude of the invention now proved to be practical beyond cavil or dispute."†

I myself well remember experiencing feelings somewhat akin to those of the Professor some eight and twenty years ago, when on board the "Agamemnon," steaming slowly into Valentia Bay, finishing the laying of a telegraph cable two thousand miles long, which extended to Trinity Bay, Newfoundland, the greater part being under water two miles in depth.

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* *Annales de Chimie*, I. xv., p. 72.

† See "Cooke's Comments on De Hamel's book," p. 70.

* "Telegraphic Railways." By W. F. Cooke.

† *Quarterly Review*, No. clxxxix. p. 125.

The apparatus used on that ever memorable occasion at Euston and Camden Town was the diamond-shaped dial instrument, with vertical needles on horizontal axes, described in the specification and shown in the drawings. The instrument required five wires, and it may be asked why should instruments like this have been employed when they had others needing but one? The reason was, that the former called for no skill in sending and receiving the messages, each letter being expressed by a simple signal of two of the needles converging to a letter. With this the inventors could easily telegraph to each other, and railway *employés* could take up the work after them without any delay, but I doubt if either Cooke or Wheatstone could have spared the time at that period to become proficient in sending or receiving a telegraphic *code*. The wires, which were laid up in a rope and placed in a trough, did not cost much in the manner they were made, though good enough for the time and the short distance: moreover, the battery-power required was small, and its action in deflecting the vertical needles to one or the other side was very simple and certain.

Thenceforward the electric telegraph prospered without a check. Wires were laid down on the London and Blackwall, and on the Great Western line between Paddington and Slough, and elsewhere. At first it was used only for railway purposes, but afterwards despatches were transmitted for the public at 1s. a message (without reference to length), which was the first popular use of the telegraph in England or in any other country. Its application soon became nearly as miscellaneous as now, affecting the highest and lowest in the land—now acquainting the Queen that Prince Albert was leaving Paddington for Windsor, now effecting the capture of thieves going down for business on an "Eton Montem Day." At one time sending the Queen's speech at Westminster for the benefit of the Royal borough, at another ordering whitebait from London, or enquiring about luggage left behind.

All at once the country was awakened to the importance of this new means of communication by the result of the following message from Slough to London:—

"A murder has just been committed at Salthill, and the suspected murderer was seen to take a first-class ticket for London by the train which left at 7.42 p.m. He is in the garb of a Quaker, with a brown greatcoat on which reaches nearly to his feet. He is in the last compartment of the 2nd first-class carriage."

A little difficulty arose in transmitting this message, for in the signals of the instruments v answered for u, and there was no q, so the word "Quaker" was spelt KWAKER, which the operator at Paddington did not at first comprehend. However, the delay was not enough to prevent proper arrangements being made for Tawell's reception.

On arriving at the Paddington Station, after mixing with the crowd for a short time, he got into an omnibus, the conductor of which was a policeman in plain clothes. Tawell, the Quaker, no doubt thought, as one passenger got in and another was put down, that his identity was getting better mixed each time. At last, reaching the Bank, he got out, paid his fare, and after crossing and recrossing London Bridge, and making many turns and doubles, he went to a lodging-house in Scott's Yard, Cannon Street. He had scarcely entered the hall when the omnibus conductor opened the door, and asked him—

"Havn't you just come from Slough?" "No," said he. He was of course arrested at once, and afterwards tried, found guilty, and executed.

The effect of Tawell's capture was a greatly increased demand for the telegraph and a great extension of the system.

Cooke, who, in his deed of partnership with Wheatstone in 1837 had reserved to himself the exclusive management of the invention and the sole control of the engineering department, found his labours prodigiously increased. To use the words of one who was with him at the time: "With his own eye and his own hand he directed all the operations in the actual erection of the first telegraphs; he literally lived, for the time being, upon the railway, making a railway carriage his shelter by day and his couch at night."*

He still held fast to his original plan of allying the telegraph with the railway, which afforded a wayleave, protection, and speedy access for repairs in case of defect in the wires; while the safety and efficiency, as well as economy in the working of the railway, were supplied by the telegraph by signalling every train from station to station and telegraphing generally throughout the line concerning engines and rolling stock.

In a book issued by him in 1842, entitled "Telegraphic Railways," I was startled to find the following: "To illustrate the practical working of these arrangements under extraordinary circumstances, I will now follow an *express*, and *therefore unexpected*, train in its course from Derby to Leicester." He then proceeds to describe the process of signalling it through its course. I have examined a "Bradshaw's Railway Companion" of the time and do not find any express, but only mail and ordinary trains. I think that an *extra* train was meant, for I find the expression used in the examination of Mr. Saunders, the Secretary of the Great Western Railway, on the 6th February, 1840, before a Parliamentary Committee† (among the members of which were Sir Robert Peel, Sir James Graham, Lord Stanley, and Mr. Labouchere, afterwards Lord Taunton). Mr. Saunders stated, in reply to Lord Granville Somerset, that the danger of collision in sending out an *extra* train, without a great interval of time being allowed between it and the ordinary trains, might be guarded against by the use of the telegraph. He also said, in reply to a previous question, that "it perfectly performs all the duty that was expected of it;" and, in reply to another question, "that it would simplify the working and diminish the stock of every description, whether of engines or carriages, besides ensuring greater punctuality; and, in cases of accident, to repair the injury with the least delay."

By the latter part of 1845 the double and single needle instruments were used everywhere, and the extent and ramifications of the telegraph had so enlarged that the time was ripe for connecting together the whole system, and forming a company for the general transmission of messages and news for the public throughout England and part of Scotland.

In this part of his original scheme Mr. Cooke was fortunate enough to obtain the co-operation of Mr. John Lewis Ricardo, M.P. for Stoke-upon-Trent and Chairman of the North Staffordshire Railway, through the introduction of Mr. Bidder, who was then the engineer of the London and Blackwall Railway and other lines.

Mr. Ricardo was a man of extraordinary sagacity and great energy. He became, and continued for many years to be, the chairman of the new corporation, which was styled the "Electric Telegraph Company." An Act of Parliament for incorporating the company was applied for in the Session of 1846.

By this time, however, there were other competitors in the field. Mr. Edward Davy had taken out a patent in July, 1838, for a telegraph in which three wires were used, and metallic points attached to magnetic needles were caused to press upon, and so to make various groups of marks upon, chemically pre pared calico at the receiving end, the solution employed being hydriodate of potash and chloride of lime. The patent was bought by the Electric Telegraph Company, but never came into use.

Other patents were also taken out in 1841, 1843, and 1845, for a type-printing, an indicating, and an electro-chemical copying telegraph, by Mr. Alexander Bain, of Edinburgh, a most fertile and ingenious inventor, who had previously devised an electric clock.

Another type-printing machine was also patented at the end of 1845, as a communication from Mr. Royal E. House, of the United States, by Mr. Jacob Brett, of which his brother wrote, in 1858, that this instrument "incurred a sacrifice on my part of many thousand pounds, without any valuable result for general purposes."*

The Electric Telegraph Company found on going to Parliament, that they were opposed by Mr. Bain, who declared, in his petition, that he had invented an electric printing telegraph, and had previously communicated his invention to Professor Wheatstone. When it came to the Lord's Committee, the Duke of Beaufort, its chairman, told the company's counsel that they had better arrange with Mr. Bain, hinting rather plainly that their Bill might otherwise be thrown out. A compromise was accordingly arranged; the company got their Bill and Bain got £12,000. His patents were transferred to the company, and he entered into an obligation to give the company the use of any further inventions. He was subsequently elected a director of the company.

Bain's prolific genius was soon at work again, and in December, 1846, he patented his electro-chemical telegraph, which consisted of a train of clockwork at each end of the line; at the sending station a paper ribbon, about half-an-inch wide, perforated with holes representing the different letters of the alphabet, as required for the message to be sent, was drawn over a conducting cylinder in connection with the earth and under a metallic spring or style connected to a battery, the other pole of which was connected to the line wire.

At the receiving station a paper ribbon, moistened with an acidulated solution of ferro-prussiate of potash, was in like manner drawn by the clockwork over a metallic cylinder connected to the earth and under a metallic style connected to the line wire.

The clockwork being set in motion, which was done by a current causing an electro-magnet to act upon a detent, the current passed through the circuit making a blue mark at the receiving end whenever the sending style passed over a perforation and came in contact with the cylinder, and leaving a corresponding blank when the sending style passed over the non-conducting paper between the perforations. The instruments worked with wonderful rapidity; the blue marks appearing to stream out from the recording style as if by magic, so that a number of operators were employed to each instrument to make the perforations in the sending paper, which was done by mechanism causing it to pass between rollers and under a punch—one hole formed a "dot," and three a "dash," of the Morse alphabet.

An experiment was tried in Paris with this electro-chemical telegraph before M. Leverrier and Dr. Lardner, in which a message of 282 words was transmitted through a continuous wire 1,082 miles in length, consisting of two telegraph wires joined together at Lille, making 336 miles, and 746 miles of insulated silk-covered wires in coils.

"A pen," says Dr. Lardner, "attached to the other end, immediately began to write the message on paper moved under it by a

* "Telegraph Manipulation." By C. V. Walker.

† "Fifth Report of the Parliamentary Committee on Railways" and *Mech. Mag.*, vol. xxxiii., 1840, p. 168.

* "Origin and Progress of Oceanic Telegraphs." By J. W. Brett.

simple mechanism, and the entire message was written in full in the presence of the Committee (each word being spelled completely and without abridgment) in fifty-two seconds, being at the average rate of five words and four-tenths per second. By this instrument, therefore, it is practicable to transmit intelligence to a distance of upwards of 1,000 miles, at the rate of 19,500 words per hour."*

I myself often saw, in the year 1847, Bain's telegraph working at an astonishing speed between Manchester and London, and have never been able to understand the cause of its being abandoned.

The only inconvenience was the occasional breakage of the damp paper when handled by the operator; but this was obviated later on by Bain having a disc of prepared paper, like a large filter paper, placed on a metallic plate of the same size, which revolved round its centre, the style having a slow motion from the centre to the edge of the disc, so that it described a spiral commencing at the centre and terminating at the edge.† In this way there was no occasion for the writer of the message to touch the paper.

It will be at once seen that Bain's telegraph was the father of the beautiful and rapid automatic instrument of Sir C. Wheatstone and Mr. Stroh now used at the Post Office, the latest speed of working which, as I am informed by Mr. Preece, is 435 words per minute, or 115 words faster than Leverrier and Lardner's experiment with Bain's telegraph.

This speed of more than 70 distinct currents passing through the line wire and the instrument in a single second of time calls to mind Juliet's

> "Lightning, which doth cease to be
> 'Ere one can say it lightens."

Nevertheless, having regard to the amazing number of currents generated in a second by the armature of a dynamo-electric machine, running at a high speed, I could not say that the limit has been by any means reached with the automatic telegraph.

Let us now return to the Electric Telegraph Company after they had come to terms with Bain and obtained their Act of Incorporation. Foreseeing the possible and, indeed, the probable contingency of other telegraphs being brought forward, they set to work, under Ricardo's guidance, to convert Cooke's contracts with the railway companies from way-leaves into exclusive agreements for a long term, so as to keep any other telegraph from passing over the line. This sagacious policy was successfully carried out, especially in the case of the leading railways and those comprising the great trunk lines from London to the north and west.

By their Act they had the power to lay pipes and wires under the streets of towns, and by the 1st January, 1848, the company opened offices for receiving and transmitting public messages in London, Birmingham, Manchester, Liverpool, and other important places, which could also communicate with the many smaller places and railway stations previously connected up. The only large towns not in communication with the central station in Lothbury were then Bath, Exeter, Plymouth, Brighton, Chatham, Oxford, and Preston.‡

The charges were, however, much too high. A message from London to

Birmingham or Stafford	cost $3\frac{9}{10}$d.	per word.
Liverpool, Leeds, or Manchester ...	„ $5\frac{1}{10}$d.	„
York	„ $5\frac{3}{4}$d.	„
Edinburgh	„ $7\frac{3}{4}$d.	„
Glasgow	„ $8\frac{3}{4}$d.	„
Derby, Norwich, Nottingham, or Yarmouth	„ $4\frac{1}{2}$d.	„

Even a lawyer, under the influence of such a tariff, became suddenly endowed with a power of writing on any subject in a most laconic style, which in his office he would have conscientiously declared to be positively impossible.

The progress of the Electric Telegraph Company was gradual, but it never flagged. In 1850, it had 1,786 miles of line and 7,206 miles of wire; in 1860, 6,541 miles of line and 32,787 miles of wire, with 3,352 instruments; and in round figures, when Government contracted to purchase the telegraphs in 1868,

> 1,300 telegraph stations in Great Britain and Ireland.
> 10,000 miles of line.
> 50,000 „ „ telegraphic wire.
> 8,000 sets of instruments.
> 3,000 skilled persons in its employ.
> 3 Continental cables under its control.§

The year 1850 was notable in the history of the company, because, owing to its high tariffs, a clamour arose for competition, and in that year Acts of Parliament were granted to the Magnetic Telegraph Company and to the British Electric Telegraph Company, which afterwards amalgamated under the name of the "British and Irish Magnetic Telegraph Company," generally known as the "Magnetic Company." I was engineer to the latter company; Mr. Edwin Clark at the time, and afterwards Mr. Latimer Clark, and following him Mr. Culley, filling the office of engineer to the Electric Company. My brother, Mr. Edward Bright, was manager, and in later years also engineer, of the Magnetic Company from its commencement to the Government purchase in 1870. Such of the railways in Great Britain as had not been exclusively secured by the Electric Company were eagerly arranged for by the new company, and nearly all in Ireland, which had not been then thought worth attention by the Electric Company. In this way, competing lines were established on the Lancashire and Yorkshire, East Lancashire, Leeds Northern, Newcastle and Carlisle, Glasgow and South Western, and throughout Ireland. To connect up with London, the Magnetic Company laid a line of ten wires in troughs along the high road by Birmingham to Manchester, continuing six wires to Preston, Carlisle, Dumfries, and Glasgow, with a fork from Dumfries to Portpatrick, for reasons which I shall soon give. On the other side of the Irish Channel another underground line was carried from Donaghadee to Belfast and Dublin, and an isolated branch from Cork to Queenstown.

These underground wires were of No. 16 gauge copper, insulated by a continuous coating of gutta percha.

This remarkable substance, which becomes soft and plastic when placed in hot water and capable of being moulded, hardening again on becoming cool, was first introduced to this country by Dr. Montgomerie, of the Indian Medical Service, who, observing that the Malays used it for making basins, jugs, shoes, and knife handles, inferred, from the crude native manufacture, that extensive uses would be found for it in Europe. He therefore purchased a quantity, and sent it, in 1843, to the Society of Arts in London.

Its value was speedily recognised; many patents were taken out for its manufacture, and its applications soon became too numerous to catalogue. What concerns us is its qualities of being a good insulator of electricity, insoluble under water, capable of being laid over a wire by being passed through a die when hot, yet being pliable and to a certain extent hard when cold.

Dr. Werner Siemens was probably the first (viz., in 1847) to use it for covering wires laid underground, but a further use of world-wide importance was soon to be found for it.

Gutta percha covered wires came into use in the tunnel wires on railways in 1847, and soon after for the wires laid in iron pipes under the streets of towns.

In January, 1849, Mr. C. V. Walker laid a length of two miles of No. 16 guage copper wire, coated with gutta percha, in the English Channel, from the sands near the Pavilion Hotel at Folkestone, where the end was connected to the 83 miles of telegraph erected along the South Eastern Railway to London. The experiment was quite successful, messages being interchanged between the chairman of the company in London and Mr. Walker, on board the steamer "Princess Clementine," at sea, with the end of the gutta-percha covered wire on board.*

A plan had been previously matured by Professor Wheatstone, as long before as 1840, for laying a submarine wire, covered with rope, between Dover and Calais, of which full particulars were given by Mr. Sabine in our proceedings; but nothing came of it, and it was not until 1850 that the first telegraph message was sent across the Channel.†

The late Mr. John Watkins Brett, to whom I have referred before in connection with House's Type-printing Telegraph, has justly been generally credited with the merit of having first taken this enterprise seriously in hand.

So early as 1845, he was imbued with the conviction of a submarine telegraph being a possibility, and with his brother, Mr. Jacob Brett, registered, on the 16th June in that year, a company for uniting Europe and America by submarine communication. He did not know of Professor Wheatstone's Channel project, concerning which, he afterwards said: "Had these facts then been known to me, I cannot say how far they might have damped my determination to devote my whole time and means to establish and promote the submarine telegraph, and, if possible, to bring this country into instantaneous communication with India and America, then the sole object of my thoughts."‡

An "Oceanic line" was also included in his brother's patent for the printing instrument,§ in which the wires were to be "coated with various colours to distinguish them."

After obtaining permission from King Louis Philippe‖ in 1847, to unite England with France by a submarine cable, followed by a concession from Louis Napoleon, when President of the French Republic in 1849—a single copper wire, covered with gutta percha to the diameter of half-an-inch, was laid on the 28th August, 1850, from Dover to Cape Grisnez, the greatest depth passed over being thirty fathoms. At every sixteenth part of a mile a leaden clamp or weight was securely fastened on to secure it in position. Messages were interchanged between the steamer "Goliath" and the English shore while the wire (which was coiled on a large drum) was being laid, and afterwards between the two shores. Next morning, however, the circuit was broken, and it was found that the action of the waves had rubbed the wire upon the rocks, and destroyed the coating of gutta percha.

The French concession stipulated that "unless the experiment shall result in a favourable execution by the 1st September, 1850,

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* "Museum of Science and Art," vol. iii., p. 117.
† *North British Review*, xliv., p. 559,
‡ *Mech. Mag.*, vol. xlviii., p. 44.
§ "Government and the Telegraphs." Effingham Wilson. 1868.

* "Electric Telegraph Manipulation, p. 102," Walker.
† *Journal of the Society of Telegraph Engineers*, Vol. v., p. 90.
‡ *Proceedings Royal Institution*, March 20, 1857.
§ No. 11,010 of 1845.
‖ "Origin and progress of the Electric Telegraph, p. 63." J. W. Brett.

the right conceded shall revert to the French Government." This object was attained, but nothing more.

A copy of the messages transmitted was attested by some ten persons, including an engineer of the French Government, who was present to watch the proceedings; this was forwarded to Paris, and a prolongation of the privilege was granted.

A more substantial cable was manufactured next year; the conducting wires consisted of four No. 16 guage copper wires, surrounding a heart of tarred hemp, and covered with a bedding of the same material. The conductors were double-covered with gutta percha to the diameter of a quarter of an inch, the core being made at the Gutta Percha Company's Works, then under the management of Mr. Samuel Statham, a gentleman of great energy and business capacity.

The outer covering was made of galvanized iron wires, laid on the core like an iron-wire pit rope. I am unable to say by whom this mode of sheathing was originally suggested, but Mr. Crampton, the engineer of the company (with whom was associated Mr. Wollaston), gave the order* for its application to Messrs. Wilkins & Weatherly, of High Street, Wapping.

They were, however, stopped by an injunction of the Court of Chancery, for infringing the patents of Mr. R. S. Newall, of 1840 and 1843,† and the manufacture was carried on by his firm. The cable, 24 miles in length and 180 tons in weight, was delivered on board the "Blazer," a hulk provided by our Government. Some delay arose from the litigation, and the manufacture was not finished until the 17th September. Mr. Crampton, who had contributed a considerable part of the capital for the undertaking, now took the laying in hand. During two stoppages, one from cessation of signals from the shore, the other from the parting of a tow-rope, a good deal of cable was wasted, and the length of cable finally proved too short by a mile. This, however, was made soon after, and spliced on to the laid part of the cable.

This cable is still in working order, although many new lengths have been inserted from time to time to make good defects caused by damage from ship's anchors and deterioration. Its type, so far as the sheathing is concerned, continues to be the model for all submarine cables laid in comparatively shallow water. A piece of the cable, as actually laid, was exhibited by Mr. Brett at the Exhibition of 1851, in Class X.; also a vertebrated iron tubular cable, and another constructed with the addition of a chain of links for the purpose of giving greater strength in dangerous situations. Drawings of these are given in the Report, and a Council Medal was awarded for them. The Submarine Telegraph Company (formed by Mr. Brett, Sir James Carmichael, Lord de Manley, and others) soon contracted with Messrs. Newall to lay a cable to Ostend. This company was the first to solve in this country, and to adopt the marvellous printing instrument of Professor Hughes (our late president), so well known by his other inventions, as for example the microphone. His printing telegraph has been employed by many foreign governments, and afterwards again by our United Kingdom Telegraph Company here; and as we all know he was the royal medallist of the Royal Society last year. The instrument of which I speak is unequalled as a wonderful example of the greatest mechanical skill in its synchronising, and all its working parts, and also of ingenious electrical application thereto. Other cables were then laid by the Magnetic Company to Ireland—between Portpatrick and Donaghadee—and the Electric Company to Holland, with others, into the details of which time does not allow me to enter.‡ These cables were, with differences in the number of wires and dimensions, all, with one exception—that between Varna and Balaclava—made in the same style as regards the outer sheathing, namely, with outer iron wires, the wire not being *twisted*, but laid on spirally, with what is termed a sun and planet motion, in which each bobbin of wire makes one turn in the opposite direction for every revolution of the machine. At the end of the year 1855, the North American lines were laid as far as Newfoundland, and in Europe the Magnetic Company's lines were completed as far as the west coast of Ireland.

The practicability of uniting the great telegraphic systems, by means of a submarine cable between the shores of the Old and New Worlds, had for a long time engaged the thoughts of some of the most enterprising men of science and of experience in telegraphs. It was yet to be seen whether a cable could be laid in such great depths of water, and continuously for so great a distance, without mishap. But there was also another problem unsettled: Could so long a circuit be worked electrically? When wires are fixed to insulators upon poles in the usual familiar manner, there is no difficulty in telegraphing through the longest circuits which can conveniently be used; but when the wires are coated with gutta percha, inductive action comes into play, and a considerable retardation of the signals takes place, arising from the wires acting in the same manner as a Leyden jar.§

Having a great length of underground gutta-percha covered wire under my control as engineer of the Magnetic Company, I carried out a long series of experiments by having the wires connected up backwards and forwards between London and Manchester, so as to form a continuous circuit of a length equal to that of a telegraph cable between Ireland and Newfoundland, or more than 2,000 miles. My method was to use a succession of opposite currents, which I had previously found to be successful with the magneto-electric instruments used by that company. I could only try my experiments at night, or on Sundays, when the traffic on the line was small.

Mr. Whitehouse, a gentleman of very high intellectual power, and a most ingenious and painstaking experimenter, had been working in the same direction for some time upon the wires of some Mediterranean cables connected backwards and forwards, so as to get a length of about 900 miles.* The use of these wires had been allowed him by Mr. Brett, who was founder of the Mediterranean Electric Telegraph Company, and on my talking of my experiments with the latter one day at Greenwich, in 1855, he brought Mr. Whitehouse and myself together, the result being that we continued our researches thereafter conjointly until the beginning of the Atlantic line, when we had to divide our labours; he becoming the electrician, and I the engineer of the company.

In July, 1856, Mr. Cyrus Field, the deputy-chairman of the New York and Newfoundland Telegraph Company, left America for London empowered by his associates to deal with the exclusive concession possessed by that company for the coast of Newfoundland, and other rights in Nova Scotia. He had, for some time, been concerned with Mr. Brett in the project. He had been here before about telegraph business, and I had discussed the Atlantic line with him in the previous year. On the 29th of September, 1856, an agreement was entered into between Mr. Brett, Mr. Cyrus Field, Mr. Whitehouse, and myself, by which we mutually engaged to exert ourselves "*with the view and for the purpose of forming a company for establishing and working electric telegraphic communication between Newfoundland and Ireland, such company to be called the 'Atlantic Telegraph Company,' or by such other name as the parties hereto shall jointly agree upon.*"

Mr. Field was—I am happy to say *is*—a man of extraordinary energy and power; rapid in thinking and acting, and endowed with courage and perseverance under difficulties, qualities which are rarely met with.

Professor Morse, the electrician of the Newfoundland Company, had also arrived in London, and Mr. Whitehouse and I showed him one night, the 9th October, 1856, at the office of the Magnetic Company in Old Broad Street, that signals could be sent at the rate of 210, 241, and, in one experiment, at the rate of 270 signals per minute, through the continuous circuit of 2,000 miles of the company's underground wires between London and Manchester.

The wires were joined backwards and forwards at Manchester and London; in each loop at both ends a galvanometer being inserted in the circuit to prove that the currents really passed through. By this the resistance, though not the *retardation* of the line, was largely increased.

On the 20th October, 1856, the Atlantic Telegraph Company was registered, Mr. Brett heading the subscription list with £25,000, Mr. Field following him for the same amount; we then held meetings in Liverpool, Manchester, and Glasgow, which were addressed by all of us, the Founders, and nearly the whole of the capital, consisting of 350 shares of £1,000 each, was subscribed for in a few days, principally by shareholders in the Magnetic Company.

I have no time to give a detailed account of the Atlantic Telegraph; it would alone occupy an entire evening, and there are several books in which it is described.†

I cannot, however, leave this hiatus without telling you what pleasurable recollections I have of those who assisted me so ably in my duties (as engineer-in-chief) in the last voyage. Mr. [now Sir Samuel] Canning, who had laid several cables; Mr. Henry Woodhouse, also an old cable layer; Mr. Everett, of the U.S.N.; and Mr. Clifford, now engineer to the Telegraph Construction Company. Irrespective of our business relations, we were all colleagues and friends together, and I never had a happier time on board ship.

Mr. Whitehouse was equally fortunate in regard to Mr. J. C. Laws, Mr. Saunders, Mr. de Sauty, Mr. Collett, and other members of his staff, whose names I cannot now call to mind.

I finally landed the first Atlantic cable at Valentia on the 5th August, 1858; and it is worthy of remark that just 111 years previously, on the 5th August, 1747, Dr. Watson astonished the scientific world by practically proving that the electric current could be transmitted through a wire hardly two miles and a half long—nevertheless he showed at the same time that the earth could be used for the return circuit.

The first messages which passed through the cable were one from the Queen to the President of the United States, and his reply. Many others followed of some importance; but this cable broke down on the 3rd September. Various causes have been

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* See letter in *The Times*, Nov. 12, 1852, from Messrs. R. S. Newall & Co., of Gateshead-on-Tyne.

† Nos. 8,594 of 1840, and 9,656 of 1843.

‡ Particulars, with drawings and sections of the earlier cables, are given in "The Electric Telegraph," by Dr. Lardner. New edition, revised and re-written by Edward B. Bright, F.R.A.S.—James Walton, 187, Gower Street. 1867.

§ There are several papers on this subject in the *Reports* of the British Association in 1854: "Experimental Observations on an Electric Cable," by Wildman Whitehouse; "On Magneto-Electricity and Underground Wires," by Edward B. Bright; "On Improvements in Submarine and Subterraneous Telegraph Communication," by C. F. Varley.

* See *Illustrated London News*, October 6th 1855, for drawing and description of Mr. Whitehouse's Apparatus. Also *Engineer*, January 30, 1857.

† *e.g.*—"The Atlantic Telegraph," by W. H. Russell, LL.D. Illustrated by Robert Dudley. Day & Sons. "The Electric Telegraph," by E. B. Bright. James Walton, Gower Street. 1867.

suggested for this: too high electric power being used, an unusually violent lightning storm at Newfoundland, and a supposed factory fault masked by the tar in the hemp, &c. I cannot give any opinion (as the cable was reported by the electricians in excellent condition after being completed by me, when it passed out of my charge), except that I agreed with Mr. Brett that the manufacture had been pressed forward with too much haste;* which view was shared in by Mr. Canning† and Mr. Woodhouse.‡ Mr. Whitehouse had wished to test every separate coating of gutta-percha during manufacture, but there was not sufficient time allowed for that to be done.

The next great submarine telegraph cable was laid from Suez, in several sections between Suez and Kurrachee, at the end of 1859 and in 1860. 3,499 miles were made and laid by Messrs. Newall & Co. for the Red Sea and India Telegraph Company, under a guarantee from Government. It was a most disappointing failure, the sections breaking down one after the other; indeed, they do not appear to have been all at work at any time for the 30 days of continuous through working stipulated in the contract.§

In May, 1859, the Government, through Sir Stafford Northcote, then President of the Board of Trade, asked the advice of Mr. Robert Stephenson and myself respecting the form of cable to be used for a submarine line, which it was proposed to lay from Falmouth to Gibraltar, 1,100 nautical miles in length, and from 100 to 2,500 fathoms in depth. In my report, I recommended a much larger copper conductor than ever used before, to weigh 3¼ cwt. per nautical mile, or 392 lbs., and the same weight of gutta-percha as the insulator.

This was precisely the same core which I had recommended the Atlantic Company to adopt in 1856, but it had all been settled by contract before I became their engineer. The relative figures in the Atlantic Cable were 107 lbs. of copper and 261 lbs. of gutta-percha. Those of the Red Sea 180 lbs. of copper and 212 of gutta-percha per knot.‖

For the outer covering of the proposed Gibraltar cable I advised different forms for the various depths—of great strength and low specific gravity for the deepest water, and of greater specific gravity for the smaller depths. This part of the report is not, however, of any importance, as the Government changed their plans, and in March, 1860, decided on laying a cable between Rangoon and Singapore, and the lighter cable, which was intended for laying in the deep water in the Bay of Biscay and which would have been quite unsuitable for the Malay coast, was abandoned. Again, in January, 1861, in consequence of the war with China having come to an end, it was settled that it should be laid from Malta to Alexandria, and divided into sections at Benghazi and Tripoli. It was accordingly laid in the summer of 1861, with great success, by Messrs. Glass & Elliot, to whom the contract for laying was given by the Government. Mr. H. C. Forde was the engineer, and Mr. (afterwards Sir) C. W. Siemens, the electrician for the Government. Full details of the construction, laying, and testing of this cable were given in two papers read at the Institution of Civil Engineers.¶ The work throughout appears to have been carried out with great care, and due regard to the conditions taught by experience to be necessary in submarine telegraphy.

The report and evidence of the Submarine Telegraph Committee was published during the construction of this cable. I consider it to be the most valuable collection of facts, warnings, and evidence which has ever been compiled concerning submarine cables, and that no telegraph-engineer or electrician should be without it if beyond reach of access to it. It is like the boards on ice marked "Dangerous" as a caution to skaters.

The next great submarine cable enterprise was the Persian Gulf line, uniting the Turkish land telegraphs at the head of the Gulf, and the Persian land telegraphs at Bushire with Kurrachee; the failure of the Red Sea line, and the loss of £800,000 over it, having led the Government of India to adopt the alternative telegraphic route by way of the Tigris Valley. A careful line of soundings was completed by Lieut. Stiffe (of what was then called the Bombay Marine) in 1862; and, the bottom being favourable for a cable, the Government of India resolved to lay one, of great strength and durability, designed by Messrs. Bright & Clark, and appointed us, in the autumn of 1862, engineers to the work. The late Colonel Patrick Stewart, R.E., was the very able Government Director of the entire line.

The total length of cable was 1,450 miles, weighing no less than 5,028 tons, being by far the heaviest length previously dispatched on one submarine expedition. The copper conducting wire weighed 225 lbs. to the knot, and the conductivity of the copper was raised to a higher point than had been attained before, amounting to nearly 90 per cent. of pure copper. In many of the older submarine cables laid before this point had received attention, the conductivity was as low as 40 per cent., and even lower.

The copper wire was made of a segmental form, surrounded by a tube, all being drawn down from a large built-up copper rod of the same construction; so that, while the wire was smooth and no interstice could be seen, it was the same mechanically as a strand, but superior electrically. The weight of gutta-percha was 275 lbs. per knot. The Government of India contracted with the Gutta-Percha Company for the core.

The laying on of the outer sheating was put up by tender upon our specification, and the contract was obtained by Mr. Henley, of North Woolwich. In putting on the outer sheathing, a wet serving of hemp was first applied with the view of discovering any defect in the insulator at once; the outer covering of 12 No. 6 B. W. G. galvanised iron wires was then applied, and over it a protective coating, respecting which I must say a few words, as it was afterwards applied to so many and such great lengths of telegraph cable. A patent was taken out in 1858 (No. 1,965) by Messrs. Clark, Braithwaite and Preece, for applying a covering of asphalte and hemp to the outer wires of a finished iron cable, with the object of retarding the decay of the zinc coating the iron wires of cables. Mr. Clark had acquired the interest of Mr. Preece (not our esteemed past-president), and, as Mr. Clark and I were in partnership at the time, I purchased Mr. Braithwaite's interest in it in 1860. It had been tried on a short length of cable laid to the Isle of Man from near Whitehaven, in 1859. The cable was passed through the hot asphalte contained in a revolving tank enclosing the bobbins of hemp. The mixture was made hot by charcoal fires outside. The insulation was damaged by this process, and the delay and injury was so great that it took more than a fortnight to get the 36 miles covered with it. Mr. Clark went away to the Red Sea in 1861. Nobody would use the patent after the Isle of Man cable experience, so I set to work to deal with the matter.

The result of my study and experiments was that I devised and patented (No. 466, A.D. 1862) the system generally adopted in all cable works since, of applying the hot compound over the finished cable by an elevator driven from the machine, making the laying on of the hemp or jute and compound one operation, and saving the delay of the former double manufacture, and also that, as the supply of compound was arrested (if the closing machine was stopped for putting in a bobbin of fresh iron wire), no damage could be caused to the insulator. The cable was then passed through semi-circular rollers (a stream of water being poured over them), by which the coating was thoroughly pressed into all the interstices of the wires. Thus the coating was done at the same time by part of the cable machinery, and the danger of destroying the insulation, and the cost, delay, and damage of re-coiling was avoided. Moreover, after a great series of experiments, I arrived at an improved composition of mineral pitch, tar, and silica made from calcined flints ground to a powder, by which latter addition the boring tool of the teredo was damaged directly it touched it. This process has been highly successful, practically as well as pecuniarily, having yielded upwards of £30,000 to Mr. Clark and myself up to the time that my patent expired.

I shall say no more about the Persian Gulf cable. I went out to lay it myself, and everything went on without any hitch or mishap. All the details will be found (including a new mode at that time of joint testing) in a paper read by me at the Institution of Civil Engineers in 1865. The cable was, and has been, a complete success.

By the date of the laying of the Persian Gulf cable, forming the first telegraphic connection between England, Europe, and India, the science of making and laying submarine lines was pretty definitely worked out, and no important improvement has been since introduced. I do not therefore propose to add further particulars relating to subsequent cables, the more so as they are to be found in many books, including our own journals and technical papers.

I should, however, observe that during my absence in India and Persia in 1864, combinations were arranged leading to the formation of large cable companies, which materially and beneficially affected the future telegraphic communication across the seas.

In March of that year, the India Rubber, Gutta Percha, and Telegraph Works Company was registered to take over the large works of Messrs. Silver—now generally called the "Silvertown Company"—and in the following month the businesses of the Gutta Percha Company and Messrs. Glass, Elliot and Company were combined as the "Telegraph Construction and Maintenance Company."

At the present time these companies and Messrs. Siemens have constructed very great lengths of cable, making the total 107,000 miles of submarine communication with all the important parts of the world, in which more than £37,000,000 capital is invested, according to calculations supplied me by Sir James Anderson.

I will advert to one further point before quitting the subject of submarine cables:—The importance of thoroughly surveying and sounding the bottom along the route where a cable is proposed to be laid has been of late years more closely carried out

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* "Evidence before Submarine Telegraph Committee," Q. 1,443.
† " " " " Q. 1,493.
‡ " " " " Q. 991.

§ The Submarine Cable Committee's Report furnishes all the evidence about this unlucky cable. Tight laying, overheating, excessive battery power, and fissures in the gutta-percha, are all spoken of.

‖ "Appendix to Report of Submarine Telegraph Committee," p. 482.

¶ *Proceedings of Institute of Civil Engineers*, vol. xxi. The first use of resistance coils for testing cables was with this cable; they had been used before for testing underground wires. See Specification of Patent, E. B. & C. T. Bright, No. 14,331, of 1852. The part referring to this mode of testing with known resistances is published in the "Submarine Telegraph Committee's Evidence," p. 53, with drawings; also, the "Museum of Science and Art," 1854, and "The Electric Telegraph," by Lardner & Bright, p. 76, edit. 1867.

than in early times, and I may remark that had this been always done, many of the failures of early cables after but a brief submergence would not have taken place.

It is only by means of taking soundings, which should not be more than ten miles apart, that an even bed can be relied upon.

Whilst laying the Lisbon-Madeira cable in 1874, the Telegraph Construction Company's ship, *Seine*, discovered a bank in latitude 33° 47′ N. and longitude 14° 1′ W., the depth being about 100 fathoms, with 2,400 fathoms in its immediate neighbourhood.

In 1879, Messrs. Siemens's telegraph ship, *Faraday*, discovered shallow water in mid-Atlantic when laying the Atlantic cable of that year.

These soundings, being of extreme practical importance for the welfare of submarine cables, are also of advantage to the scientific world generally, in increasing the knowledge of the depths of the sea and the nature of its bed.

The Silvertown Company has given particular attention to this subject, as described in a paper, "On Oceanic Shoals discovered in the Steamship *Dacia*," read before the Royal Society of Edinburgh, in 1885, by Mr. J. Y. Buchanan, F.R.S.E.

Before starting to lay the cable, the telegraph steamers *Dacia* and *International*, in 1883, sounded from Cadiz towards the Canaries on two separate zig-zag routes; and over 100 soundings were taken in this way by each ship at distances of 10 miles apart.

In the course of these soundings the *Dacia* discovered a bank in latitude 31° 9′ 30″ N. and longitude 13° 34′ 30″ W., and depth 58 fathoms, in the vicinity of a 2,000 fathom depth: or, about the height of St. Paul's Cathedral from the bottom to the surface as compared with some of the highest Swiss mountains. These soundings were in what otherwise might have been taken as the line of the Canaries cable.

In 1885, and last year, the telegraph steamer *Buccaneer*, belonging to the same company, made close surveys and soundings down the West Coast of Africa to a point as far south as St. Paul de Loanda, with a view to laying cables there; and the results were given by Mr. Buchanan in a paper read at the Royal Geographical Society in November last. There were over 1,000 soundings taken, besides noting the strength of the currents along the coast, which is considerable.

I regret that time does not now allow me to do more than refer briefly to the means of doubling the transmitting power of cables by the highly ingenious duplex system invented by the Messrs. Muirhead, which is now applied most successfully to about 50,000 miles of submarine lines.

Duplex telegraphy as applied to cables has been brought to a high degree of perfection, judging from the results that have been obtained on the Mackay-Bennett cables recently laid across the Atlantic. The system is simply a "bridge" method, in which two sets of condensers are kept balanced in connection with the cable and the artificial cable, without the insertion of wire resistance to any great extent.

Dr. Muirhead informs me that on the New York and Canso cable of 826 knots the ordinary working rate was 21 words per minute, but when the duplex system was applied the rate of transmission was actually doubled, being 42 words per minute. Also, that on the long Atlantic cable of the same system between Canso, Nova Scotia, and Waterville, Ireland, of 2,353 knots, while the ordinary telegraph instruments gave a speed of nearly 16 words per minute, the duplex apparatus has yielded 30½ words—equal to an increase of 93½ per cent.

Referring again to the English telegraph companies and to their acquisition by the State; opinions have often been expressed that the Governments of the time made an improvident bargain, but I think I shall be able to show that such was not really the case.

While the telegraph lines of the various countries in Europe Asia, India, and in our Australian colonies, were erected and worked by their respective governments, in England not only the first telegraphs were started by private enterprise, but so carried on for 33 years (1837 to 1870) until purchased by Government.

During this long period those engaged in the undertaking had provided the capital, incurred all the risk, and developed the telegraph system into a highly lucrative business, from which the profits, notwithstanding competition, were steadily increasing, so much so, that the net earnings of the two largest companies (the Electric and Magnetic) ranged from 14 to 18 per cent. per annum.

The companies were not desirous of parting with the systems they had created, but the transfer to Government was very strongly advocated by the press and others.

Without, however, giving the companies particulars beforehand, a Government Bill was brought forward suddenly, as shown by the following extract from a pamphlet published at the time by Effingham Wilson, entitled "Government and the Telegraphs."

"On Wednesday, the 1st April, 1868, the new Chancellor of the Exchequer, Mr. Ward Hunt, appeared at the table of the House of Commons to move for leave to introduce one of those anomalous measures known in Parliamentary phraseology as 'hybrid' Bills (*i.e.*, public Bills affecting private rights), to enable Her Majesty's Postmaster-General to acquire, work, and maintain electric telegraphs. . . . . Mr. Ward Hunt rose to ask leave to introduce this Bill at 25 minutes before 6 o'clock. The House of Commons adjourns its Wednesday discussions at a quarter before 6 o'clock. The Chancellor of the Exchequer had, therefore, only ten minutes to develop 'the objects' of the Bill. Having fully exhausted those ten minutes, the Speaker intimated that the hour for terminating the discussion had arrived. Mr. Milner Gibson and Sir Charles Bright rose to address the House, but they were too late even to ask a question or obtain an answer, much less to raise any discussion on the principle of the measure."

The Bill as at first framed was very arbitrary, and practically looked like confiscation; but in view of the strong opposition of the companies, the Post Office authorities came to terms by agreeing to 20 years' purchase of the net profits—that is to say, that Government acquired property yielding them 5 per cent. on the amount they paid, which they were able to raise at about 3 per cent.

A Parliamentary Committee, consisting of the Chancellor of the Exchequer, Mr. Goschen, and others, then sat nine days, and thoroughly thrashed out the conditions of the Bill in July, 1868, while a Conservative Government was in power, and the terms arrived at were confirmed next year by the Money Bill brought in by a Liberal Government.

Before the completion of the purchase at the beginning of 1870, the accounts of the companies were thoroughly investigated by accountants of the Post Office, and the existing plant was examined by their experts.

The total paid to the telegraph companies was £5,847,347, of which the Electric and Magnetic had £4,182,362, the balance being divided between the following smaller companies—United Kingdom, Reuter's, and London and Provincial.

Most of the railways had telegraphs of their own, and derived revenue from messages, and also in some cases from payments made to them by the telegraph companies for way-leaves and other privileges. The value of these to Government was subsequently fixed by arbitration at £1,817,181.

Upon national considerations the Government quickly extended the wires to a vast number of small places, which, though a great boon to the community at large, entailed a very large extra cost, especially as the capital outlaid in such extensions has been debited in the accounts as part of the charges against the revenue of each year. The reduction of the message rates to one shilling also entailed loss at first. These facts account for the Postal Telegraph Department not having profits to show such as made by the companies.

Bearing upon this, I may mention that the companies handed over, in 1870, 48,378 miles of land wire and 1,622 miles of cable wires (irrespective of the railway wires worked by them), connecting together 2,488 telegraph stations; while at the present time the Post Office have no less than 153,153 miles of wire (including submarine wires used for commercial purposes) in communication with 5,097 offices. Thus the mileage has been trebled and the stations doubled. There are also 17,042 miles of wire used for private purposes. In addition to this the railway companies have about 70,000 miles of wire, making a gross total of 240,195 miles; and the weight of the iron wires employed is no less than 50,150 tons.

The following comparison of tariffs and messages for the past 30 years is interesting:—

Year.	No of Messages.	Tariff and Remarks.
1855 ...	882,360 ...	1s. 6d. to 4s. Address free.
1860 ...	1,863,839 ...	Do. do.
1865 ...	4,650,231 ...	1s. to 2s., and a 6d. rate in certain large towns.
1869 ...	*7,500,000 ...	* Estimated for year preceding transfer.
1870 ...	9,850,177 ...	1s. tariff for 20 words. Address free. † October to October.
1875 ...	19,253,120 ...	
1880 ...	26,547,137 ...	
1884–5...	†33,493,224 ...	
1885–6...	47,508,509 ...	6d. tariff for 12 words. Address counted. Also October to October.

I should, however, remark that on separating the inland messages in the last two returns from the foreign, press, &c., messages, the great immediate increase by the change of tariff becomes more evident, as these figures give 24,615,395 messages in 1884–5 sent at the shilling, and 37,692,249 in 1885–6 at the sixpenny rate; and for the last six months under review the inland sixpenny messages were at the rate of more than 42 millions per annum. The receipts have also turned the corner, showing an increase of £5,526 over the corresponding period of the shilling rate in 1885. This is partly accounted for by more *extra* words being now used by senders, the average amount paid per message being now 8½d., while under the shilling rate it was 1s. 0½d.

I am indebted for these later statistics to the Postal Telegraph authorities—Mr. Patey, C.B., Mr. Graves, and Mr. Preece, F.R.S., all members of our council. If time had permitted I intended to describe Professor Sir William Thomson's beautiful apparatus for working through long cables, and also his system of taking deep sea soundings by the use of a small, steel wire, which is generally adopted. Nor have I been able to refer to telephones which may be regarded as a branch of the telegraphs.

In conclusion, I beg to thank you for the consideration and patient attention you have accorded to my long address.

Mr. E. GRAVES proposed a vote of thanks to Sir C. T. Bright for his address, which gave a lucid account of the early rise and development of English telegraphy, and which bristled with facts in connection with a system in which Sir Charles Bright had, in many of the achievements, taken a conspicuous part.

Mr. W. T. ANSELL, as one of the pioneers remaining in active service, seconded the motion, which was heartily accorded.

A ballot for the election of new members took place, and the meeting adjourned until Thursday, January 27th.

CORRESPONDENCE.

Secondary Batteries.

After reading the letter from Mr. Sellon in your last issue, one hardly knows whether most to pity or to admire his genius. It appears that his ideas and patents have once more been pirated, this time in a most "barefaced" manner.

We all know that there is nothing new under the sun, but we have to learn by constant reminder that years ago Mr. Sellon managed to appropriate everything that had been or could be done in connection with secondary batteries, and to embody the same in a series of patents, some twelve in number.

Alas for those who have been steadily working for the improvement of these batteries, the hope and sheet anchor of the electrical engineer! Their ideas are old, and they cannot hope for success; has not Mr. Sellon tried the same thing "some five or six years ago, under *all conceivable conditions*," and—failed?

But though he failed he did not neglect to patent, having, indeed, in view the possibility of someone trying the same thing at a future date—and possibly succeeding.

Knowing something about the work which was being done in the direction of solid peroxide plates, of the various patents which have been taken out, and of the patentees and others who have been connected with the work which has resulted in the bringing out of the "Union" battery, I have looked forward to the *début* of this battery with much interest, as being a decided advance upon anything that has yet been done in a practical way, and did I not possess this knowledge I might, perhaps, have been led to regard Mr. Sellon's letter as a serious production. But knowing what the "Union" battery is (which, by-the-way, Mr. Sellon does not), and being able to read between the lines of his letter, I have no difficulty in assigning to that production its true value.

Mr. Sellon should really have seen the battery himself, or sent a representative who would have given him a true and detailed report, before endeavouring to substantiate a prior claim, and he would then, perhaps, at least have avoided crediting the Union Company with such light and airy fancies as keeping the hydrogen elements in a dry condition. His appeal to the experts of the company to test and publish the extent to which these elements will lose their charge, "say, for the limited time of 24 hours," reads like a scientific clincher; only that, unfortunately for the effect it is intended to produce, the company does *not* adopt this method of dealing with these plates.

Mr. Sellon has, indeed, some misgiving in his own mind as to whether he has not made a slip here, for he adds: "unless zinc is employed," so that it would appear he is really so ignorant of the construction of the battery that he does not even know of what the positive element consists.

Then, again, it is absolutely impossible for him to conceive that a solid peroxide plate may be successfully used, inasmuch as five or six years ago he made "very *natural* endeavours" to manufacture the same under "*all conceivable conditions*." Well, we must suppose that since then the endeavours of others have been *un-natural*, perhaps even *super-natural*, to have succeeded; they have certainly taken a considerable time (nearly three years), and the plates now brought forward have been tested under every—but no; I must stop here.

Mr. Sellon must really post himself up in what has been, and what can be, done with the solid peroxide plate, which is really the backbone of the "Union" battery, before attempting to discredit the same, or to lay claim to a priority of invention.

The letter signed "H. A. K." under the same head is more reasonable, and points to some little experience with this form of plate; but that experience is much behind the best that has been done in this direction.

To those who know the secret of producing a peroxide plate which combines the necessary mechanical and electrical properties, there is no difficulty in obtaining a capacity of 16 ampère-hours per pound, with no trace of sulphate, no signs of disintegration even after the most severe use, and a rate of discharge to meet any given requirement which can be named.

Acid.

In reference to the new battery brought out by the Union Electrical Power and Storage Company, Limited, I imagine that Mr. Sellon flatters himself when he says that he has been imitated. If, as I understand is the case, the Union Company has acquired the "Lithanode" patent, they can certainly do better than to follow on the lines laid down by that gentleman.

I have had the curiosity to obtain the patent specification from which Mr. Sellon has given some extracts, and I am at a loss to understand how he can have been so ill-advised as to put this forward as an anticipation of the "Union" battery.

It would be most interesting to publish this short specification *in extenso*, as a fine example of what is technically termed a "fishing" patent. Not only would it be impossible for an expert to construct, without the exercise of extraneous invention, anything in the nature of an effective battery plate on the basis of this specification; but it is impossible to comprehend from it more than this: that the "inventor" imagines he can claim *en bloc* all materials "not readily subjected to the destructive influence of oxidation," and that he includes amongst these *wood*, *papier mâché* and *cellulose* (not *celluloid*).

The owners of such patents frequently exhibit a touching faith in their prospective efficacy; but it would be well for them to bear in mind that patents of this character can be utilised only as the Chinese utilise their wooden cannon, viz., to produce a moral effect upon those who are not "in the know."

Perhaps the best advice that could be given to those initiators of improvements whose action may be impeded by "fishing," or "dummy" patents, is to read and inwardly digest the chapter on "The provisional specification" in Mr. E. Morton Daniel's excellent treatise upon "The new law of patents, &c."

$\Delta\ \phi$.

[We would refer $\Delta\ \phi$ to p. 49.—EDS. ELEC. REV.]

My company have been informed that the Electrical Power Storage Company have to-day written a letter to the Union Electrical Power and Light Company stating that the batteries referred to in a printed description issued by the latter company are an infringement of certain patents held by the E. P. S. Co.

As my company have sold the letters patent under which these batteries are made to the Union Company, I am instructed to say that such batteries are not an infringement of any letters patent owned by the E. P. S. Co., and furthermore that within the last month counsel's opinions have been taken, careful investigations of specifications have been made at the Patent Office, both of which clearly show that the E. P. S. Co.'s patents are not novel, have been anticipated, and are consequently invalid so far as they have anything in common with the patents sold to the Union Company.

The Union Company are, I understand, prepared to defend any proceedings that the E. P. S. Co. may see fit to take, and so are we. The E. P. S. Co. must be aware from past experience that the position they take up is untenable.

D. Armytage Davis, *Secretary*,
THE PRIMARY BATTERY CO., LIMITED.

January 13th, 1887.

[The foregoing letter of Mr. Davis, identical with that to which Mr. Sellon refers in his opening paragraph, reached us last week, but too late for insertion.—EDS. ELEC. REV.]

Referring to my letter of the 8th inst. on the above subject, will you allow me, in consequence of one from Mr. Davis, secretary of the Primary Battery Company, which appeared last week in a contemporary, to encroach once more upon your space?

That gentleman speaking on behalf of his Company, of the Union Company and of their Counsel, arrogates to himself the office of Judge, Jury, Appeal Court, and House of Lords combined, declaring invalid the patents of the Electrical Power Storage Company, and stating that the manufactures of the companies in which he is interested are no infringements.

I would request all who are interested in this matter to be good enough to read my patent specification, No. 5,631, of 1881 (the one referred to in my letter of the 8th), and also those which I am given to understand are the mainstays of the Union Company, viz.: Fitzgerald and Jones, No. 15,777, 1884 (as to the last paragraph of the final and claim 6), and Jones, No. 5,045, 1885 (as to the whole of the specification and all the claims), and I think they will arrive at the conclusion that such claims consist of little more than verbose amplifications of the points distinctly set forth in my above referred to specification (of more than four years earlier), and so far as they are material appear to be fully covered by the one simple claim then made by me.

I have, this day, seen a plate of the Union Company's manufacture—I find it consists of a *compressed slab of active material placed in a frame of celluloid, fixed to a portion of such frame, in combination with strips of platinum forming the terminal.* If this plate had been placed before me in December, 1881, I do not think I could have described it more concisely or more definitely than in the words I then wrote and in the claim I then made. Assuming, therefore, that Mr. Davis's gratuitous (not to say libellous) assertion as to the invalidity of my patent is correct, how about those of the Union Company taken out in 1884, 1885, for precisely the same object and in practically the same words?

John S. Sellon.

January 15th, 1887.

[As we have been asked by several gentlemen whether the Union battery could be recommended for electric lighting in private houses, we venture to ask the following questions:—

(1.) For what space of time has any complete set of the Union Batteries been continuously at work for regular lighting purposes?

(2.) What is the largest size and capacity of plate as yet made, and what approximate percentage of those made have been successful?

(3.) In what manner is the evaporation of the quicksilver (used for contact making) prevented—are the vendors aware that such evaporation takes place at ordinary temperatures, unless hermetically sealed or covered with some such substance as oil, glycerine, or paraffin, which cannot be used under such conditions, also that the molecular dissipation of mercury when any strong electric current passes through it is considerable, to say nothing of any loss by sulphating, oxidation or spilling?—EDS. ELEC. REV.]

I have now been using the electric light for a year in my house, and I venture to send my experience with the storage cells as I think it may be of use to others. To begin with I had 20 15-L glass E.P.S. cells of 330 ampère hours capacity; but, unfortunately, the dilute acid was put in the cells several days before the dynamo arrived, so that the plates were badly coated with white sulphate of lead before the charging commenced. The greatest current that could be got out of the dynamo was 10 ampères, and the average charging current about 8 ampères, this, I suppose, was too small for the type of cell (for which I see the rate ought to be 25 ampères) as the sulphate instead of disappearing got worse and the plates began to buckle, and in appearance both + and − plates were nearly alike, both being covered with a hard white sulphate. I was told that the cells were probably ruined, and that the only chance of saving them was to increase the dynamo and engine power. However, I determined to try an experiment which I tried with success four or five years ago on some of the "Faure" cells. Into one of my E.P.S. cells I put about a pound weight of carbonate of soda (ordinary washing soda), I then charged with the same current I had previously used, and soon noticed that the plates in the cell containing the soda showed signs of improvement, and gradually the peroxide plates entirely lost their white appearance and became a beautiful dark brown, and the finely divided lead plates also regained their proper metallic colour. None of the other cells showed the slightest alteration in appearance, but all remained thickly coated with white sulphate, although the same current had gone through all.

When I found that my experiment appeared to be attended with success, I put the same quantity of carbonate of soda into all the other cells. I then charged as usual, and after a few days the whole of the cells entirely altered in appearance, the peroxide plates having become a beautiful dark brown, and the other plates a clear clean metallic grey colour. I have now used them for nearly a year with perfect satisfaction, and although I have sometimes left them for more than a fortnight without charging, I have never again seen any appearance of the hard white sulphate, neither have the plates buckled. Should you think my experience of any value to others, perhaps you will find space in your valuable paper for a few lines on the subject.

W. J. S. Barber-Starkey.

[The results of Mr. Barber-Starkey's experiments are remarkable, and we do not remember to have come across a similar experience. It would be interesting to know, however, whether the introduction of the washing soda materially alters the internal resistance of the cells, but in any case we think our correspondent's example will be widely followed. Perhaps Mr. Sellon, Mr. Drake, or Sir David Salomons may have experimented in this direction?—EDS. ELEC. REV.]

Short Circuiting Bells.

Permit me to point out that the system of circuits for electric bells, described in your issue of January 14th (p. 28) by Mr. Wennman, is practically identical with that used for some months in Germany for telephone bells. A description of the latter may be found in the *Elektrotechnische Zeitschrift* for 1883. The differential systems of Mr. P. Jolin and Mr. Averdieck are to my mind simpler: they have fewer moving parts and contacts to get out of order, and they permit of a number of bells being set in one circuit. In Mr. Wennman's bell, the forward movement of the hammer first short circuits the electro-magnet at one pair of contacts, and then opens the electro-magnet circuit at another pair of contacts. I greatly doubt his contention, or rather opinion, that this will give a more rapid action to the hammer than the differential arrangement of the bell circuits, as used by Mr. Jolin.

S. P. Thompson.

Honour to whom Honour.

I listened attentively to the Presidential address of Sir Charles T. Bright at the Society of Telegraph Engineers last night, and I received two impressions from that address, which have so stuck in my mind that I wish to know whether others have received the same, or whether I am labouring under some illusion of the senses.

The first is, that in the subject of oceanic telegraphy neither Varley, nor Fleeming Jenkin, nor Sir William Thomson have taken any part worth naming.

The second is, that if a man goes to Germany and sees there a new and beautiful application of scientific principles (shown in a public lecture by some other

person) he may afterwards come over to England and patent the same thing in principle, be awarded honour and glory for *his* invention, and be upheld in Presidential addresses as the inventor.

If I have heard wrongly, I shall be glad to be set right.

A Dullboy.

A "New" Arc Lamp.

Your paragraph on p. 39, relative to M. Desson's "new" arc lamp, states that the use of a "motor" to work the feed mechanism is not new, having been used by Edison "many" years ago. The fact is, Edison's was patented in 1881 (No. 2,495), and that the motor in the lamp does not operate the feed, which is an ordinary clutch device. The motor of Edison's lamp merely spins the upper carbon round to make the consumption more uniform. Lamps had been invented previously by André (1880) and by Tchikoleff (1874) in which the feed was operated by a small motor.

No Side.

January 14*th*, 1887.

Electro-Magnets and Idle Wire.

An idea prevails that the ordinary horse-shoe magnet only utilises one-half of the available lines of force. Drs. Hopkinson have shown this to be untrue by their experiments; but, from the reports of the meetings of the Society of Telegraph Engineers, it appears that many still believe it to be true. The idea is based on the principle that lines of force form a closed curve round the wire carrying the current.

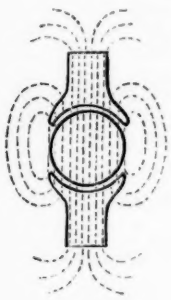

FIG. 1.

FIG. 2.

Fig. 1 shows an electro-magnet in its simplest form, with the armature in the centre, and when bent round it becomes fig. 2, which becomes the ordinary type of single horse-shoe magnet, as shown in fig. 3, by the addition of a yoke, and is again developed into fig. 4 by adding a second horse-shoe magnet.

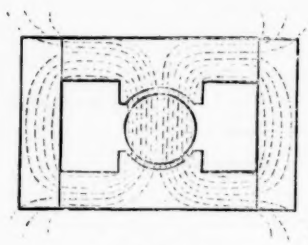

FIG. 3.

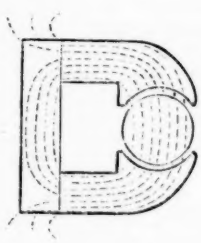

FIG. 4

It will be seen that the advantage gained by fig. 3 over figs. 1 and 2 is that *the magnetic resistance* (if we may use the term) *which one-half the lines of force have in their path is very much smaller than the other half have to encounter*. By inserting this you may correct an erroneous idea.

Richard P. Fuge.

January 15*th*.

A New Primary Battery.

I must apologise for again writing to you so soon, but since reading the account of Mr. Walker's battery in your last issue, it occurred to me that if sulphur was melted and run into perforations, or even dropped on the surface of a carbon plate, it would adhere very firmly, and possibly render the use of a porous pot unnecessary. If there is any advantage in the plan no doubt it has been already tried by Mr. Walker, but I venture to send two p'ates by post for your inspection, as, according to some hasty experiments I have tried, they appear to yield very good results.

The smaller of the enclosed plates has been in use for 10 consecutive hours, and at the end of that time, according to my voltmeter, the E.M.F. was $1\frac{1}{4}$ volt.

W. J. S. Barber-Starkey.

January 18*th*, 1887.

Text Book on Steam and Steam Engines.

In your able and very complete review of my "Text Book on Steam and Steam Engines" in your last week's issue, you remark that you find important matter choked out, such as the Corliss valve gear, hand-regulated expansion gear, marine engine governors, &c. When I tell you that I had very great difficulty in finding room for the many illustrations and their explanations as found in the book, owing to the limited space placed at my disposal and the desire to produce a text book at a price within the means of the general science and art student, you will understand my difficulties. Several important lectures, including the various devices mentioned above, had to be omitted, but these, as well as the other errors and defects pointed out in your and other reviews will, as far as possible, be included and amended in future editions.

Your review does good to the reader, the author, and the publisher, for it points out in a straightforward manner what you find amiss, instead of merely extracting a few lines from the Preface, as reviewers too often do.

The book only costs students 5s. 8d., whereas, owing to the numerous diagrams (about 200) and the four folding plates, I am informed that it should have cost more like 12s. 6d. I am glad, however, to be able to say that a second edition has been already called for, and I shall be only too glad to receive any criticisms, however severe, from any of your numerous practical readers, with a view to improving the book.

Andrew Jamieson,
Principal, College of Science and Arts, Glasgow.

January 17*th*, 1877.

[We are aware that publishers often hamper authors considerably by limiting the number of pages and diagrams, as well as by trying to induce them to use old cuts, to the great disadvantage of all concerned, author, publishers, and readers. A text book, now-a-days, on any practical subject, is not worth buying unless it is well illustrated with diagrams up to date. We have, however, much pleasure in stating that Mr. Jamieson's text book has secured, evidently from many firms of repute, a greater number of good diagrams than we have observed in any similar book.—EDS. ELEC. REV.]

Manganese Dioxide.

At the end of your description of Mr. Sidney F. Walker's sulphur battery you state that the above oxide is a conductor of electricity. I believe that is the generally accepted fact. Some little time ago I tried manganese dioxide as a substitute for carbon in the microphone, but found it a perfect non-conductor. I was unable to obtain a deflection even with 100 Daniells.

R. Frederick Yorke.

January 18*th*, 1886.